Jebel Ali New Town

This Report is respectfully dedicated to

HIS HIGHNESS SHEIKH RASHID BIN SAEED AL MAKTOUM

without whose foresight, inspiration and guidance this project would never have materialised

Jebel Ali New Town

Terms of reference

On the 9th September 1976, we were commissioned by His Highness Sheikh Rashid Bin Saeed Al Maktoum, Ruler of Dubai, to prepare an overall plan for a new town at Jebel Ali, following the decision to provide a new port and an International Airport, together with a substantial industrial complex, in this area.

Our terms of reference were to:-

i Provide the conceptional framework for future development and examine and suggest the layout of the infrastructure of the area.

ii Examine the provision of all the basic services, ie water, drainage and power supplies, and suggest how they might be accommodated and provide information on the basic road and transportation network with particular reference to the possible realignment of the main Dubai/Abu Dhabi road.

iii Suggest the location of the various components of the town, in conjunction with the proposed industrial element, and make recommendations on the siting and layout of the related residential areas, together with ancillary functions such as educational and medical facilities and shopping areas.

iv To give particular attention to landscaping and the creation of an attractive environment for those who will live and work in the area, and make recommendations as to how such needs might be met.

v Liaise closely throughout with the Municipal Authorities and Halcrow Middle East Limited the consultants retained for the new port and airport project.

vi Prepare the report in six months, with an interim report after three months. This restricted timetable was dictated by the fact that construction work on the harbour and some of the basic industries had commenced and it was essential to establish an overall framework for the town and the basic infrastructure provision at the earliest possible date. The airport and port developments are the subjects of separate reports by Halcrow Middle East Limited.

Foreword

The creation of a new town is a challenge to planners and architects, but more significantly it presents an enormous opportunity for its founders.

However, the creation of Jebel Ali is more than just a challenge and an opportunity. It is perhaps unique in that it can be planned without being hampered by the constraints which normally circumscribe all new towns in more developed locations, and is undoubtedly unique in that it will enjoy a massive injection of capital at the outset, not only to provide a port and airport of international standards, but also to provide a substantial industrial base to safeguard its future welfare.

The policy of investing oil wealth in industrial prosperity has been successfully pursued by HH The Ruler of Dubai over the past decade, and this policy will reach its zenith in Jebel Ali. The development plan set out in this report provides the framework for the gradual evolution and expansion of a new town, with new homes and new facilities for its inhabitants appropriately located to service the airport, the seaport and the related industrial activities.

In submitting this report we wish to emphasise the importance that we attach to two principal recommendations.

First, to succeed as a pleasant place in which to work, this town must have a heart and a soul — a centre — and this report suggests the form and location of such a centre. From this centre the town will grow as it responds to the needs of the people and the demands of its ancillary commercial activities. Secondly, we consider that its growth must be planned, regulated and monitored, and to this end we strongly recommend the creation of a Development Agency, responsible for the implementation of the overall plan of the town, assisted by the team of professional consultants who assisted in its birth.

We suggest that the construction of the centre of Jebel Ali might be undertaken by such a Development Agency, to provide the leadership, impetus and incentive to individual developers in the surrounding areas, and to provide the nucleus of an attractive environment in which to live and from which to direct its fortunes. A town without a centre is like a hawk without its plumage; it will look unattractive and it cannot perform its ordained functions.

In compiling the ensuing report outlining a framework for the creation and evolution of Jebel Ali, we are conscious of the responsibility that we have shouldered and the value of the contributions that have been made by a large number of individuals and organisations. But above all we are conscious of the foresight and imagination of HH The Ruler, who conceived the project and provided the necessary drive and determination to translate the idea into reality.

PEDDLE THORP CHAPMAN TAYLOR
February 1977

المقدمة

يعتبر بناء مدينة جديدة تحدياً للمخططين والمعماريين ولكنه يعطى بصورة أكثر أهمية فرصة كبيرة لمؤسسى المدينة .

وعلى كل فأن تأسيس جبل على هو أكثر من مجرد فرصة وتحدى . ربما كان أمراً فريداً من حيث أنه يسمح بتخطيط مدينة بدون التقيد بالقيود التى تحدد عادة جميع المدن الجديدة فى الاماكن الأكثر عمراناً ومما لا شك فيه أن جبل على مدينة فريدة من حيث أنها ستتمتع فى بدايتها باستثمار رأس مال ضخم ليس فقط لتوفير ميناء ومطار جوى على مستويات دولية ولكن أيضاً لاعطاء قاعدة صناعية واسعة تضمن للمدينة الرفاه فى المستقبل .

وقد أتبع صاحب السمو حاكم دبى خلال العشر سنوات الماضية سياسة توظيف الثروة النفطية فى التقدم الصناعى بكل نجاح . وستصل هذه السياسة ذروتها فى جبل على . يعطى المخطط الاعمارى الوارد فى هذا التقرير الاطار اللازم لتطور المدينة الجديدة وتوسعها التدريجى ببناء بيوت جديدة ومرافق جديدة لسكانها فى أماكن مناسبة لخدمة المطار والميناء والمؤسسات الصناعية المرتبطة بذلك .

وفى تقديم هذا التقرير نود أن نؤكد الاهمية التى نوليها لركنين رئيسيين من توصياتنا .

أولا ، للنجاح كمكان لطيف يعمل فيه الأنسان ، لا بد لهذه المدينة من قلب وروح لها — أى مركز — ويقدم هذا التقرير اقتراحاً بشأن نوعية ومكان مثل هذا المركز . ومنه ستنمو المدينة باستجابتها لمتطلبات السكان ومقتضيات النشاطات التجارية الثانوية . ثانياً ، نرى ان من الضرورى التخطيط لنموها وضبط ذلك ومراقبته . ونوصى لهذا الغرض بكل شدة على ضرورة ايجاد وكالة اعمار تتحمل مسؤولية تنفيذ المخطط العام للمدينة بمساعدة فريق من الاستشاريين المهنيين الذين ساهموا فى انشاء المدينة .

نقترح اقامة مركز جبل على يد مثل هذه الوكالة للاعمار وذلك لاعطاء القيادة والحوافز والقوة الدافعة للافراد المهتمين بالاعمار فى المناطق المجاورة ولتوفير قلب ذى محيط جميل للحياة يبنى منه مستقبل المدينة . ان مدينة بدون مركز أشبه بنسر بدون ريش . أنها ستبدو دميمة ولا تقوى على تحقيق وظائفها المنشودة .

وفى تحضيرنا لهذا التقرير الذى يبيّن الهيكل العام لتأسيس وتقوية جبل على شعرنا بمسؤوليتنا التى أخذناها على عاتقنا وبقيمة المساهمات التى قدمها عدد غفير من الافراد والمنظمات . ونشعر فوق كل شىء ببعد النظر والتصور الذى اولاه صاحب السمو حاكم دبى الذى توصل إلى فكرة المشروع وأعطى القوة الدافعة له والعزم لنقل الفكرة إلى حيز الواقع .
يناير ١٩٧٧

بدل ثورب شابمان تيلور

يناير ١٩٧٧

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Existing situation

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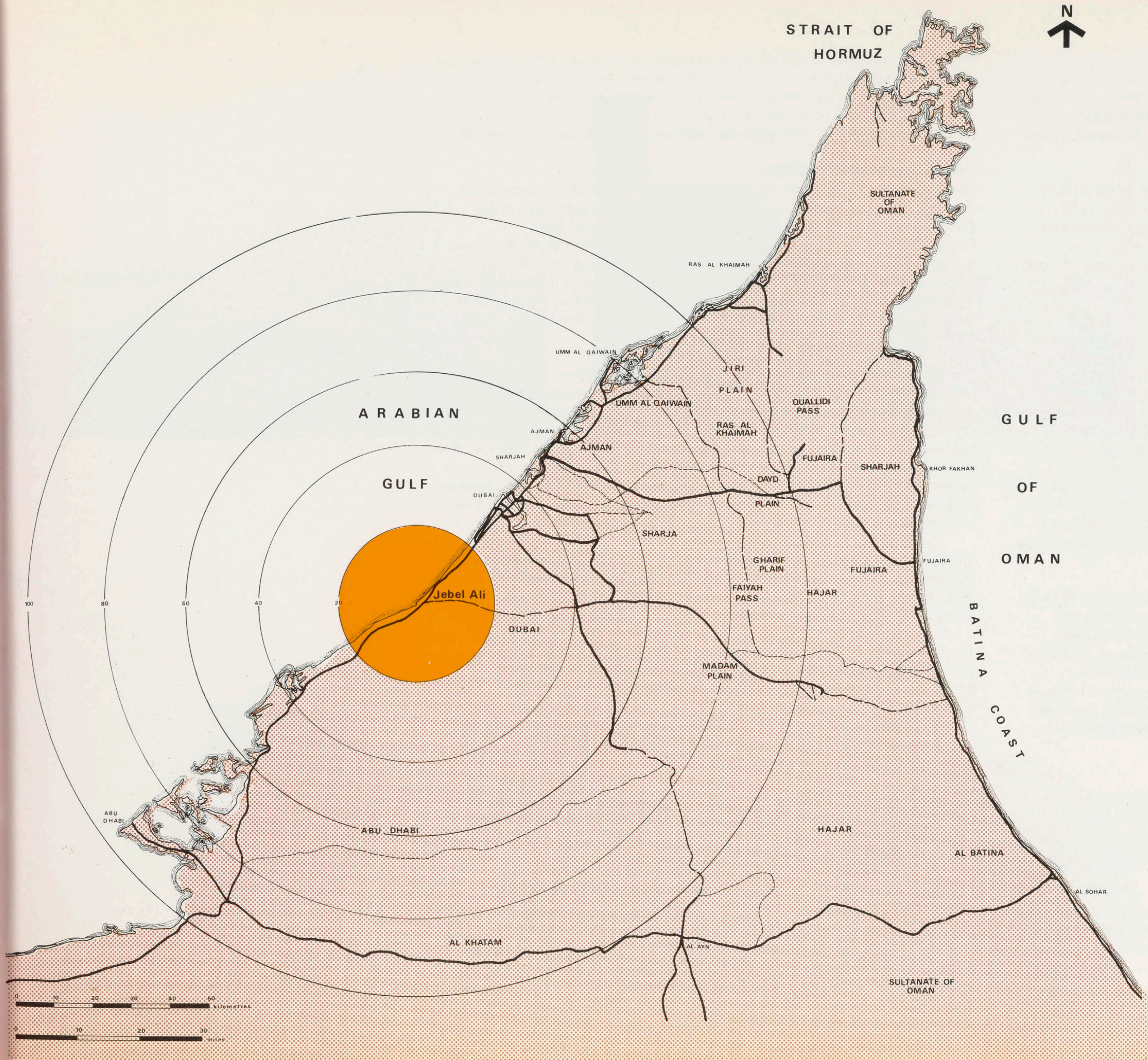
United Arab Emirates road map



Chapter 1
Background

Location

Dubai is one of seven members of the Federation of the United Arab Emirates, and is located on the West Coast of the Musandam Peninsula in the Arabian Gulf, and occupies an area of about 3885 square kilometres. The cosmopolitan population totals some 210,000 and includes Indians, Iranians, Pakistanis, as well as a large number of Europeans and Americans.

The Emirates extend some 644 kilometers along the south coast of the Arabian Gulf between the Sultanate of Oman and the Qatar Peninsula and the 1975 census gave their total population as 653,565 divided principally between Abu Dhabi and Dubai. Jebel Ali is strategically located between these two major centres of population at the intersection of the developing regional road network, figure 1.

Trade

Dubai was the leading centre for trade and maritime enterprise for the eastern end of the Gulf long before oil was discovered, and until 1968 the economy depended entirely on port and entrepot trade with the northern states of the Federation as well as into the interior of Oman. Active trade takes place with Southern Iran, India and Pakistan. A tradition of free enterprise has been built up and encouraged by liberal trading policies, moderate import duties and minimal transit levies, all of which have strengthened the geographical advantages which Dubai enjoys. Dubai has always benefited from its natural deep water creek which can take vessels up to 800 tons and to keep abreast with changes in shipping, the new Port Rashid was constructed with associated storage facilities. This port has greatly enhanced Dubai's pre-eminence in trading activities in the Gulf and when fully operational will provide 57 berths and a protected water area of 465 hectares.

The tonnage landed at Dubai has increased from some 1,855,000 tons in 1973 to 4,000,000 tons* in 1976 and it is estimated by the Department of Ports and Customs in Dubai that some 40-50 per cent of total imports are re-exported. Unfortunately it is not possible to trace how imports are redistributed. While the volume of exports to the other Gulf states by sea is recorded, the overland movement, which is assumed to comprise the major part of the re-export cargoes is not, but it does tend to emphasise that Jebel Ali's strategic location at a major intersection of the developing Regional highway system will play a significant part in maintaining Dubai's trade dominance.

Oil

The Fateh oil field was discovered in 1966 and the south-west Fateh field in 1970; discovery of a third offshore field, subsequently called the Rashid field, was made in 1973. Exploratory activity is being carried out offshore in northern Dubai waters and close to the Abu Dhabi/Dubai border, where gas has already been discovered in Abu Dhabi waters.

The commercial oil fields are about 93 kilometres from the coast and the water is shallow, both of which dictate that oil is not brought to shore for loading into tankers from an onshore storage base in the conventional manner, but is stored and loaded completely on the field. The offshore construction work for oil and gas production is a significant industry looking after the needs of 61 wells and their supporting storage tanks and vessels, and the industry is likely to expand as oil production increases as anticipated in the next three years from the Fateh and South West fields, and could get a further boost if any other fields are developed. Current oil production from Dubai's oil fields is estimated to be about 330,000 barrels per day, though there are expectations that this will be increased to 400,000 barrels per day this year. This increase in activity would be aided considerably by the improved facilities that are projected at Jebel Ali.

*Estimated by the Department of Ruler's Affairs and Petroleum Affairs.

Dubai's development programme

Dubai's economy is primarily dependent on revenue from oil production and trade and the Government has undertaken a number of projects to enhance Dubai's position as the leading trading entrepot in the Lower Gulf. Communications have been strengthened by the construction of the Deira road tunnel at the mouth of the Dubai Creek and a second bridge has been built further upstream. Port Rashid is now being extended to make it the largest and most modern port in the Middle East and a new Trade and Exhibition Centre is under construction. Dubai's International Airport was the first airport in the Lower Gulf to meet the needs of large modern jets.

The Government also intends to diversify the economy and has embarked on an industrial development programme to broaden Dubai's economic base. The first stage, in the form of a dry dock and cement plant, is nearing completion. The dry dock, adjacent to Port Rashid, will be the largest in the world, capable of handling one million ton tankers, and the cement plant will be the largest in the Gulf with a production capacity of 500,000 tons per annum of high quality cement from local raw materials. The cement plant is located some 14 kilometres south west of Dubai, on the road to Jebel Ali, and completion is scheduled for early 1978.

The process of economic diversification is to be accelerated by the development of a new industrial town at Jebel Ali, some 35 kilometres south-west of Dubai, as the centre of Dubai's industrialisation programme, figure 2. Current Government Plans provide for the construction of the following major projects.

1 An aluminium smelter of 135,000 tons per annum and ancillary facilities.
2 A liquified petroleum gas plant.
3 A steelworks of 500,000 tons per annum capacity.
4 A steam power station.
5 An international airport, with both passenger and major cargo facilities.
6 A 75 berth port complex with facilities specifically designed to meet the requirements of the above projects.

It is also proposed that all the construction works for oil and gas production should be transferred from Dubai to Jebel Ali. A massive Free Trade Zone and light industrial area is also planned together with other major industries, such as a refinery, and a petro-chemical complex are being considered.

Work has commenced on the port. The construction of the breakwaters and wharfs is being undertaken by Balfour Beatty Construction Limited in a joint venture with Dubai Transport Company; Rock and Raw material is being provided under a contract negotiated with Futtaim/Wimpey Limited; and the dredging work is being carried out by Gulf Dredging and Costain Blankevoort International Dredging. The Consulting Engineers for the project are Halcrow Middle East Limited. It is intended that five berths will be available in 18 months time to meet the needs of the aluminium smelter complex.

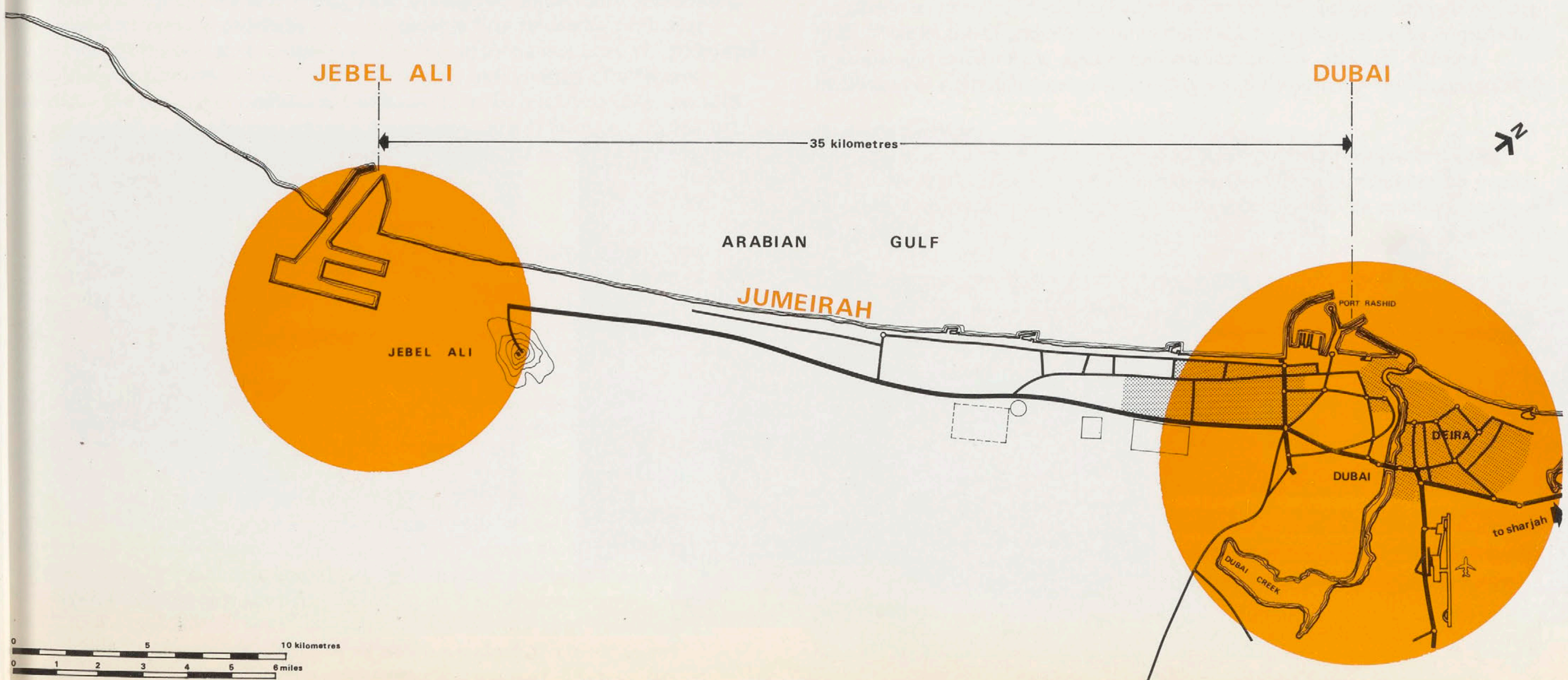
The twin towns of Jebel Ali and Dubai will complement one another, Jebel Ali becoming the main industrial location with its port and airport providing for full international needs, and Dubai continuing to develop as the social, commerce and administrative centre.

2
Location

Harbour works at Jebel Ali

Houses in Jumeirah

Dubai



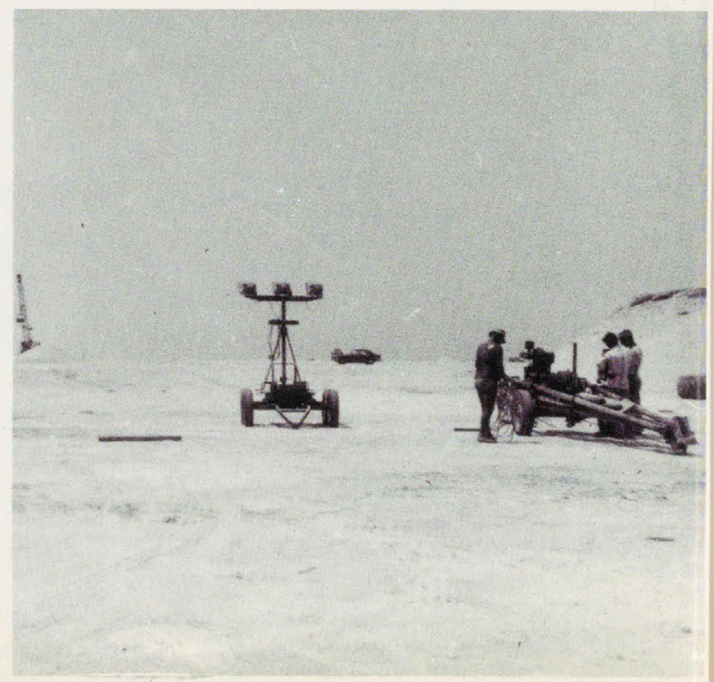
The aluminium industry was chosen by the Government of Dubai as one of the cornerstones of the development programme, because of its export orientation and its potential for related – downstream – activities. In May 1976 a contract was placed by Dubai Aluminium Company ('Dubai') with British Smelter Construction Limited ('BSCL') for the construction and commissioning of this smelter complex with its associated power station, and site works are currently taking place. In 1979 production could start with an output of 20,000 tons rising to 135,000 tons by 1981. The smelter will employ over 1,800 people and will provide major direct and indirect benefits to the Emirate. An associated extrusion plant is to be built by BSCL for Gulf Extrusions and is due to be completed December 1977.

The Liquified Petroleum gas plant ('LPG') for Sunningdale Oil is programmed for completion by the end of 1978. Hudson Engineering of Houston are responsible for the engineering design, and the output of the plant at around 60 million cubic feet a day will be almost totally consumed by the nearby aluminium smelter. The steel plant will be operated by Ferrostaal, a West German concern from Essen.

British Consultants Kennedy & Donkin are responsible for the design of the electricity power station and desalination plant at Jebel Ali. The station will be steam powered and consist in the first phase of three units of 60 megawatts each. The Dubai Electricity Company originally intended that the station would serve Dubai town, but the station has been so designed to provide second and third phases to supply the energy requirements of the Jebel Ali New Town.

Dubai has always benefited
from its natural deep water creek

The coastline west of the new port looking back from the new
breakwater to the harbour construction site



Preparatory works on the
aluminium smelter site

Chapter 2
Site characteristics

General

A full contoured survey has been undertaken of an area in the immediate vicinity of the port, industrial zone and airport area and this information has been augmented by an aerial survey study and ground inspection of the areas to the west and east of the port. The aerial survey, figure 3, gives some indication of possible ground levels, dune heights and their movements. The preliminary ground inspection and information from a series of borehole logs taken on the harbour site gives evidence of the broad pattern of subsoil strata.

Generally the land rises sharply from the sea edge to about 10 metres and then gradually slopes down towards the Abu Dhabi/Dubai Road and then gently slopes up to between 20-25 metres above sea level over a distance of some 10 kilometres. The only landscape feature is the Jebel Ali 'mountain' which rises to a height of 70 metres. Vegetation is extremely sparse and offers neither constraint nor guidance to the siting of the town.

Based upon previous experience in construction work on sites in Dubai and Abu Dhabi it is anticipated that the subsoil strata will include soft to moderate limestones, dolomites, marls, chalks, calcerious sandstones and calcerious sands which can appear as hard cemented layers or be extremely loose. In addition, layers of permeable pure fine shell material may be present. Frequently a reasonable limestone/sandstone bedrock strata is encountered within ten metres of the surface. However, the overlying layers of sandy shelly subsoil are often variable in density and strength with no realiable pattern. There is a general absence of silica/quartz type rocks, but in waddi beds weathered rocks from outcrops are present in varying sizes, and are referred to as gravels on the map.

The borehole logs and visual evidence from the harbour excavations substantiate the above assumptions and show that a reasonable firm cemented sand layer exists close to the surface in places and is underlaid by a thick layer of carbonated rock. The ground does, however, appear to have a high content of sulphates present in the form of crystalised deposits, which being readily soluble, can lead to a weakening in the soil/rock structure if exposed to moisture, in addition to their more usual characteristic of having highly aggressive elements potentially dangerous to concrete construction.

Area west of the port

In the area west of the harbour and adjacent to the existing road from Dubai to Abu Dhabi there are extensive salt flat or subkha areas. The level of these flats is clearly relatively low and the very nature of the flats indicates the close proximity of the water table. It follows that such low lying areas can be subject to flooding either by sea water or by surface water due to run off from adjoining ground in wet seasons. These subkha areas are almost certain to have high concentrations of aggresive elements both in the soil and the ground water, due to evaporation processes and the mechanical strength of the ground can also be affected by the proximity of the water table.

There would appear to be no overriding reason, from the information so far obtained, why satisfactory construction work should not be carried out in this general area. Low lying areas such as the subkha flats will require treatment, including both filling and drainage to render them more suitable for building. Development on the area covered by sand dunes is likely to be more difficult owing to the presence of fine uniformly graded calcerious sand. Levelling, consolidation and stabilisation works would be required before moderate construction loading was possible.

Jebel Ali Hill area

Rocky outcrops are visible in the area, but without drilling boreholes it is not possible to predict with any certainty the likely nature of the ground. No difficulty is expected in finding ground sufficiently strong and stable to support the normal construction loads but it may be that the surface profile of the rock outcrops is unsuitable and to undertake any extensive modification could involve expensive blasting operations. In this area there are also clear indications of dry waddi beds and we would advise the avoidance of construction work in these as the ground is very liable to flash flooding in the rainy season when these waddi beds become small rivers in a matter of moments following a rainstorm.

We recommend that construction works should only be undertaken in this area if further detailed site investigation reveals that they could be carried out without too much complication and expense.

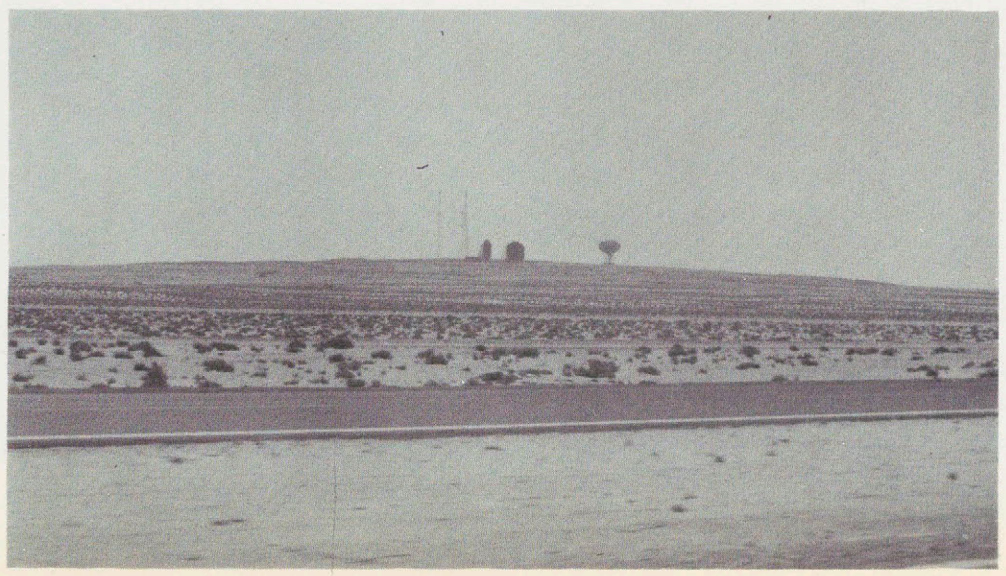
Foundation and building height

Experience in foundation design construction in the area, and the anticipated presence of the cemented sand and carbonated rock stratas occurring generally throughout the coastal site, suggests that there will be no difficulty in providing adequate bearing for normal building structures. For single storey and other low rise buildings it is anticipated that either specialist spread footings or modified raft type foundations can be provided. For buildings of more than two storeys there should be no difficulty in providing piled foundations to carry the necessary loads.

If consideration is given to buildings in excess of two storeys in height then, for optimum efficiency of structural elements and building services, consideration should be given to buildings between five and ten storeys high. Many buildings both of lesser and greater height than the range suggested are being constructed in Dubai and clearly these can be built without undue difficulty, but the likelihood of achieving maximum efficiency will be better in the suggested range.

Sand stabilisation

The township could affect the local wind currents in its immediate vicinity, causing some modification of the normal pattern of sand drifting and it might be prudent to consider clearing and stabilising an area on the wind-ward side of the township.



Telecommunications Centre on the Jebel Ali hill

Chapter 3
Climate

Jebel Ali is in a position approximately 25°N latitude and 55°E longitude and its coastal location makes the summer not only hot but oppressively humid. The seasons of the year can be identified approximately as follows:

Spring	A short transitional period during April and May when the daytime temperature rises rapidly. Cloud amounts decrease at this time.
Summer	This is the hottest season during the period June to September, when dry bulb temperatures can reach 47°C and above. There is hardly any rainfall and skies are usually cloudless. Dust and sandstorms can be frequent and haze often occurs.
Autumn	This occurs during October and November and brings somewhat cooler conditions although it still remains very warm.
Winter	The period December to March brings the coolest weather and is the time when the cloud amounts are at their greatest. Most of the scanty rainfall falls at this time. Strong winds and squalls can occur during this season accompanied by dust or sandstorms.

Information on climatic conditions is limited but it is sufficient to allow some basic conclusions to be made, which may be summarised as follows:

1 Rainfall is so scant that it will prevent planting unless artificial irrigation can be constantly maintained.

2 The temperature in summer ranges between 39°C and 47°C and winter temperatures are relatively high, averaging some 20°C, therefore the maximum protection from sun radiation that is reasonably possible should be provided.

3 Humidity remains at near saturation levels for long periods in summer. It is the main element of discomfort and air movement either natural or from mechanical ventilation is essential.

4 The wind rose indicates the main wind speeds and directions, the west to east and south to north being the most predominate. On a typical day the wind blows in off the sea during the morning and afternoon and rotates round in a clockwise direction to blow off the land during the night.

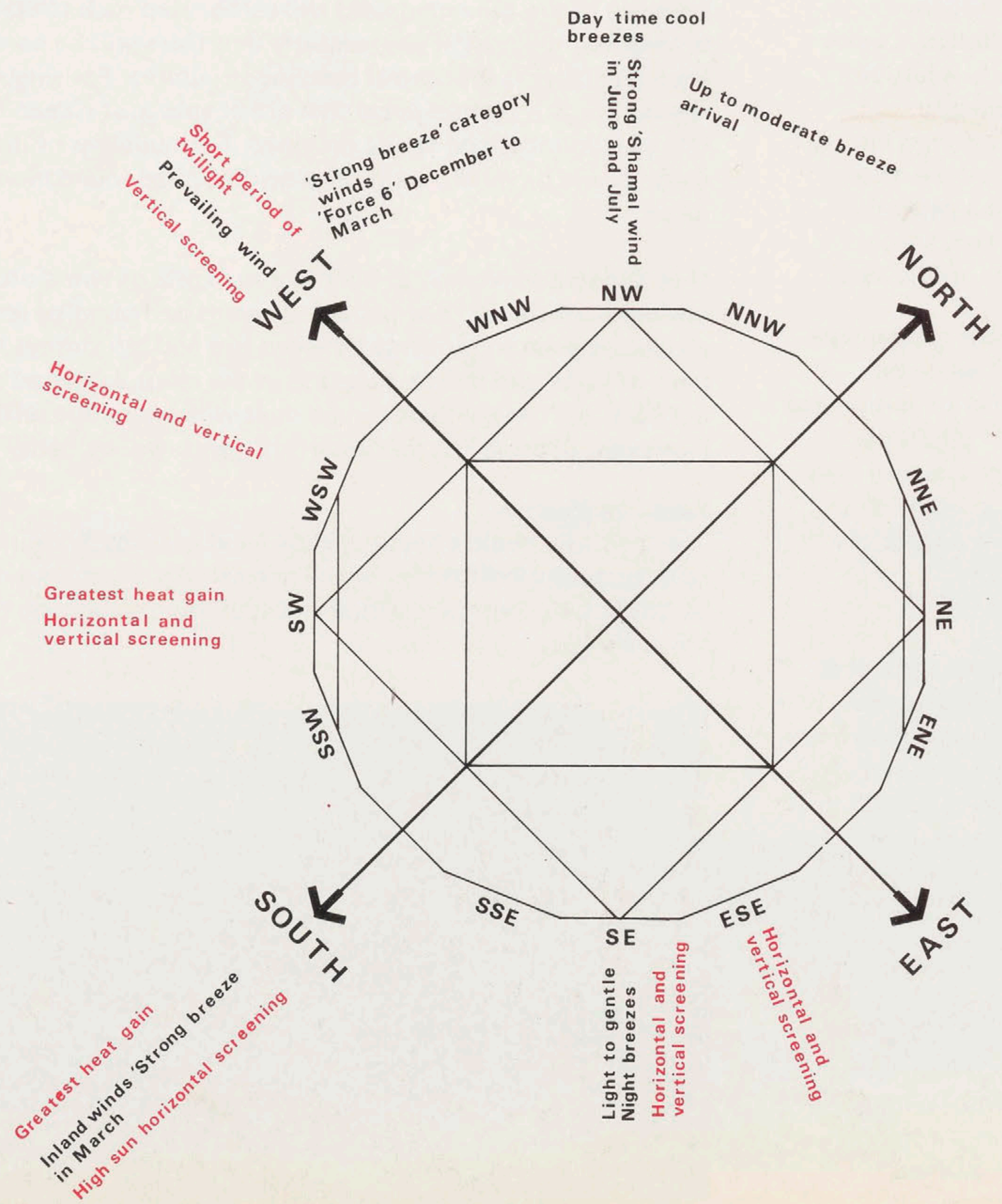
The atmosphere could retain dust and fumes from the industrial development as there is no general air turbulance, as in, say, europe, to dissipate the particles. During the day the sea breeze gently carries any polluted air inland only for the night air to bring it back again. There is an essential need to filter waste, gas, smoke, etc. from all harmful effects. As an additional safeguard residential accommodation should not be located where it could suffer from wind blown pollution.

During summer, sandstorms may occur approximately on the line of the south wind arrow. The quick air movement along the ground picks up sand, silt and light debris in a rotating mass. They are not freak occurrences and must be planned for, not only because of their dehydrating effects but also because of their ability to cause damage by their own force and with the dust they carry.

The wind must be lifted, deflected and slowed at every opportunity, and artificial linear hills on the town's periphery are recommended.

These desert conditions mean that buildings and humans need protection from sun and for a short time in the year from rain, but because of the heavy humidity, air movement becomes of paramount importance, since the moving air helps to relieve acute discomfort. The interior of buildings should be shaded and large external overhangs and arcades should be provided where possible. Buildings are subject to expansion and contraction at a rate unknown in non-tropical areas. Cracks, warping and sand and wind erosion are inevitable unless proper care is exercised in the choice and detailing of building materials.

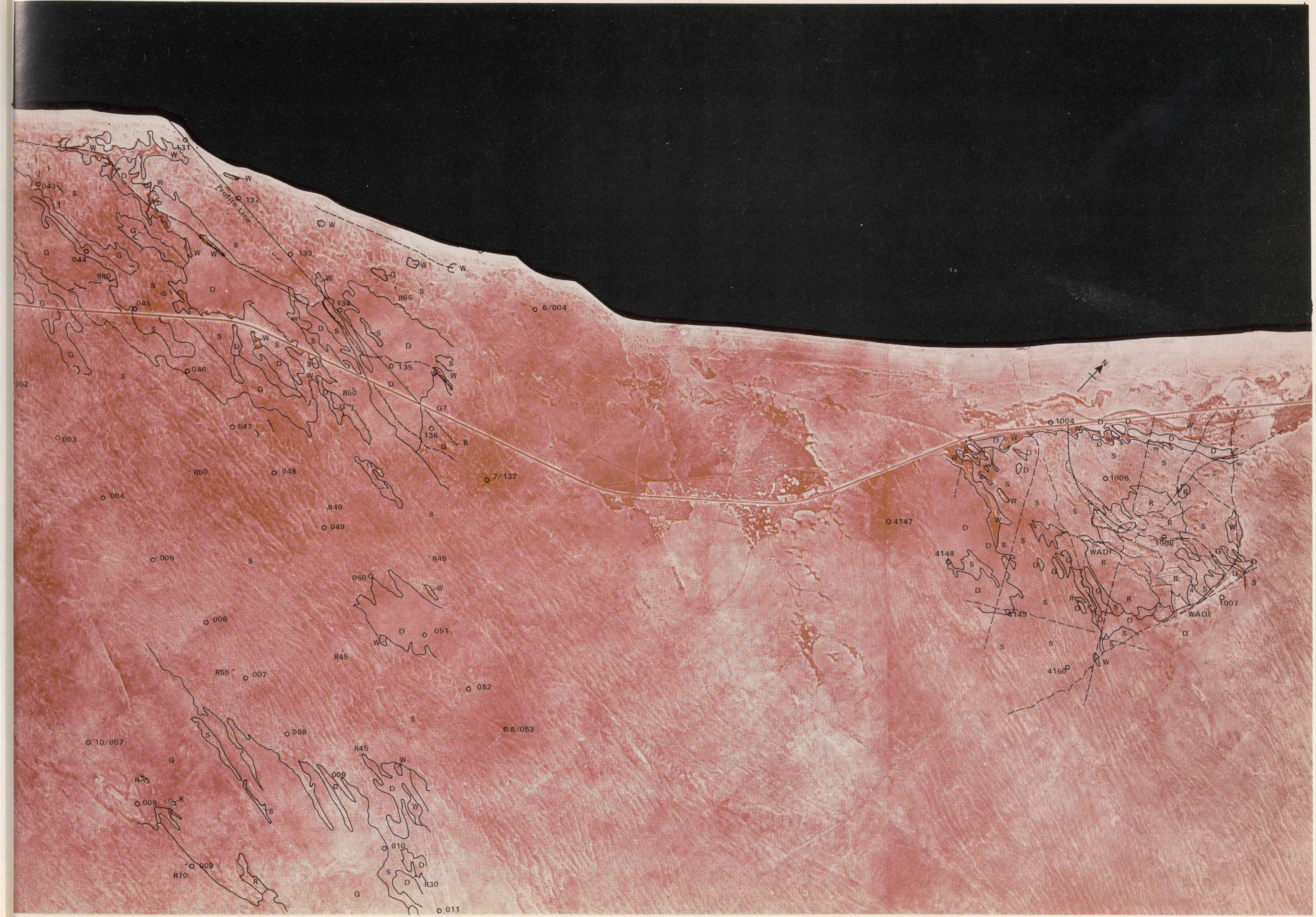
Appendix A gives a more detailed analysis of climatic conditions in Dubai.



3
The site

The land slopes gradually towards the sea. The terrain is similar to that encountered throughout the Emirate and preliminary investigations indicate that satisfactory construction works could be carried out in the area, though the rock outcrops around Jebel Ali hill might present local problems.

W	wet sebkha
D	dry sebkha
S	sand dunes
G	gravel plain
R	rock outcrop
R6.5	relative height of sand dunes in metres (approximate).
0 10/007	principal point of photograph.



043
044
R80
045
131
132
Profile Line
133
134
R65
6/004
135
046
002
R50
136
047
003
R50
048
7/137
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R40
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1004
1005
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WADI
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Chapter 4
Engineering services

Water supply

All potable water is being drawn from the same systems supplying Dubai. These plans consist of a 300 mm (12") main being installed along the main coastal road to supply up to 900 cubic metres per day (200,000 gallons per day) to be followed by a 600 mm (24") main following the more direct route along the quarry road. It is anticipated this main will be commissioned by the end of 1977 and will have a capacity of 28,000 cubic metres per day (6,000,000 gallons per day).

These supplies are primarily for construction purposes associated with the power station, smelter, harbour and other major construction projects in the Jebel Ali area with the associated housing sites and infrastructure. The pipelines will ultimately supply a reservoir at a high point on Jebel Ali hill of 30,000,000 gallons capacity (three days production from power station desalination plant). A further low-level reservoir adjacent to the power station of 100,000,000 gallons capacity (three days production of aluminium smelter desalination plus some additional storage.

Items of the plant which will be erected in the power station and in the smelter plant will utilize waste heat to desalinate sea water and each will produce eventually up to 30,000,000 gallons per day. The resulting product will be pumped into the reservoir for future distribution to Jebel Ali and the industrial areas.

The above figures indicate that sufficient water will be available to support the proposed development at Jebel Ali.

Waste

At present in Jebel Ali the only work in progress is construction of major civil engineering projects, each with their own accommodation and facilities for waste disposal. Each site has its own sewage disposal system with the treated effluent being reused where possible. No organized or co-ordinated system exists at present for the disposal of domestic or industrial refuse, and it is expected that temporary tips will be allocated on each site, which will require cleansing at the end of the construction periods.

Electricity

No electricity is available at present but provision is made within the projected overall electrical grid system for the area for 132 kV overhead transmission lines to link Jebel Ali with other towns.

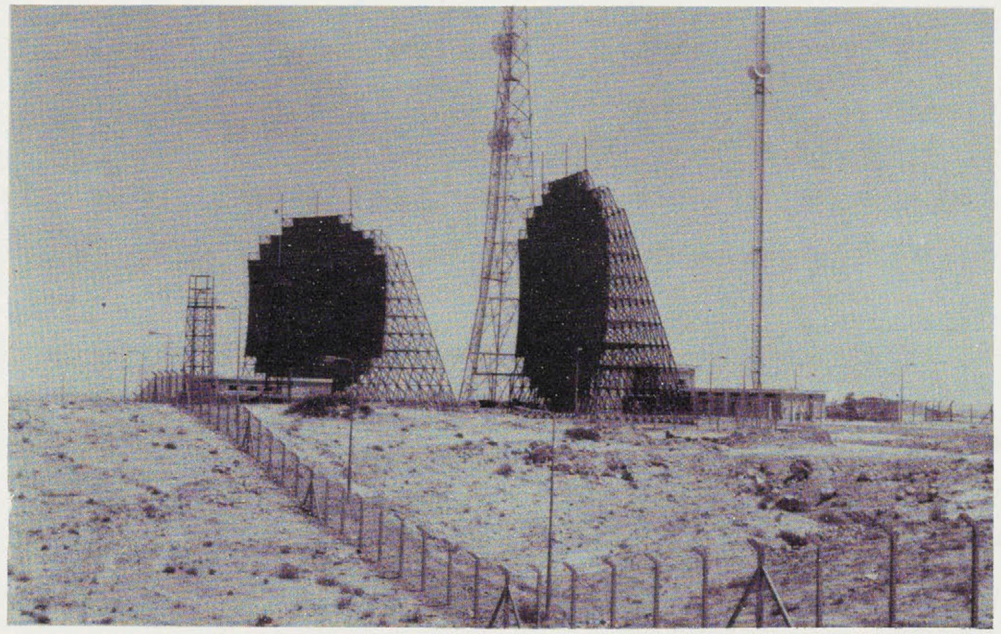
A power station is presently being constructed which is based on five 60 MW steam turbine generators to be installed progressively followed by further steam turbine generators of a larger size. Heat is to be recovered and used in a desalination plant.

The first phase of the power station consists of three 60 MW sets which will provide power for Dubai.

The power requirements for the new town at Jebel Ali will necessitate the ordering of additional generating plant and associated transmission and distribution equipment all of which has been outlined by the D.E.C. consultants.

Telecommunications

The State of Dubai is a participant in the Emirates Telecommunications Commission, the operating companies of which are Cable and Wireless and International Air-Radio Ltd. (IAL). The former are concerned with international communications and already have in operation a centre on the Jebel Ali. IAL already have equipment planned for the major users in the Jebel Ali area, connected to the Dubai system.



Gas

It is anticipated that after providing for the larger industrial users, any surplus of these supplies will be made available to domestic or smaller industrial users in bottled form.

The site viewed from the
Abu Dhabi/Dubai road

2

Summary

Dubai's economic prosperity depends upon crude oil production and trade but it is the Government's intention to diversify the economy to increase Dubai's role as the leading trade entrepot in the Lower Gulf and to broaden Dubai's economic base beyond the traditional trading activities by establishing new export orientated industries.

Jebel Ali, a site some 35 kilometres south-west of Dubai is to be developed as the centre of Dubai's industrialisation programme. Work has already started on the 75 berth port complex and under current Government plans the first stage of the industrial complex will include an aluminium smelter and ancillary facilities; a liquified petroleum gas plant; a steelworks; a power station and desalination plant, and an international airport; it is also proposed that all the construction works for oil and gas production should be transferred to Jebel Ali from Dubai. In addition to these prime industries there will be a substantial light industrial and free trade zone together with the public utilities necessary to service the area. By 1981 some 32,000 people could be working in the industrial complex and the new town could be housing some 67,000 people rising to 347,000 in 1996 and possibly 529,000 by the year 2007.

The distance between Jebel Ali and Dubai makes it unrealistic to assume that the majority of the people who will eventually work in Jebel Ali will live in Dubai. The new town at Jebel Ali must therefore provide all essential services, but without detracting from Dubai as the capital city for the region. Jebel Ali will become the main industrial location, with its port and airport providing for full international needs. The decision to relocate the construction works for oil and gas production and to house the main power stations for Dubai at Jebel Ali will strengthen Jebel Ali's role as the industrial centre and illustrates how the twin towns of Jebel Ali and Dubai will complement one another. The relocation of industry from Dubai will free valuable sites along the creek for attractive commercial, residential or recreational activities, thus assisting Dubai's continued expansion as the social, commercial and governmental centre. It is currently estimated that if all the developments now under active consideration in Dubai are undertaken, the overall population figure by the year 2007 could be 758,000.

The overall population at Jebel Ali will be determined by a number of factors, not least being the success rate in attracting industry into the area. For this reason we have placed particular emphasis on the creation of a pleasant environment. An industrial town can be an unattractive place in which to work and live and numerous studies have shown that subjective judgement plays as important a part in investment decision as a cost-benefit analysis. The appearance of an area can therefore be crucial to the prospective industrialist.

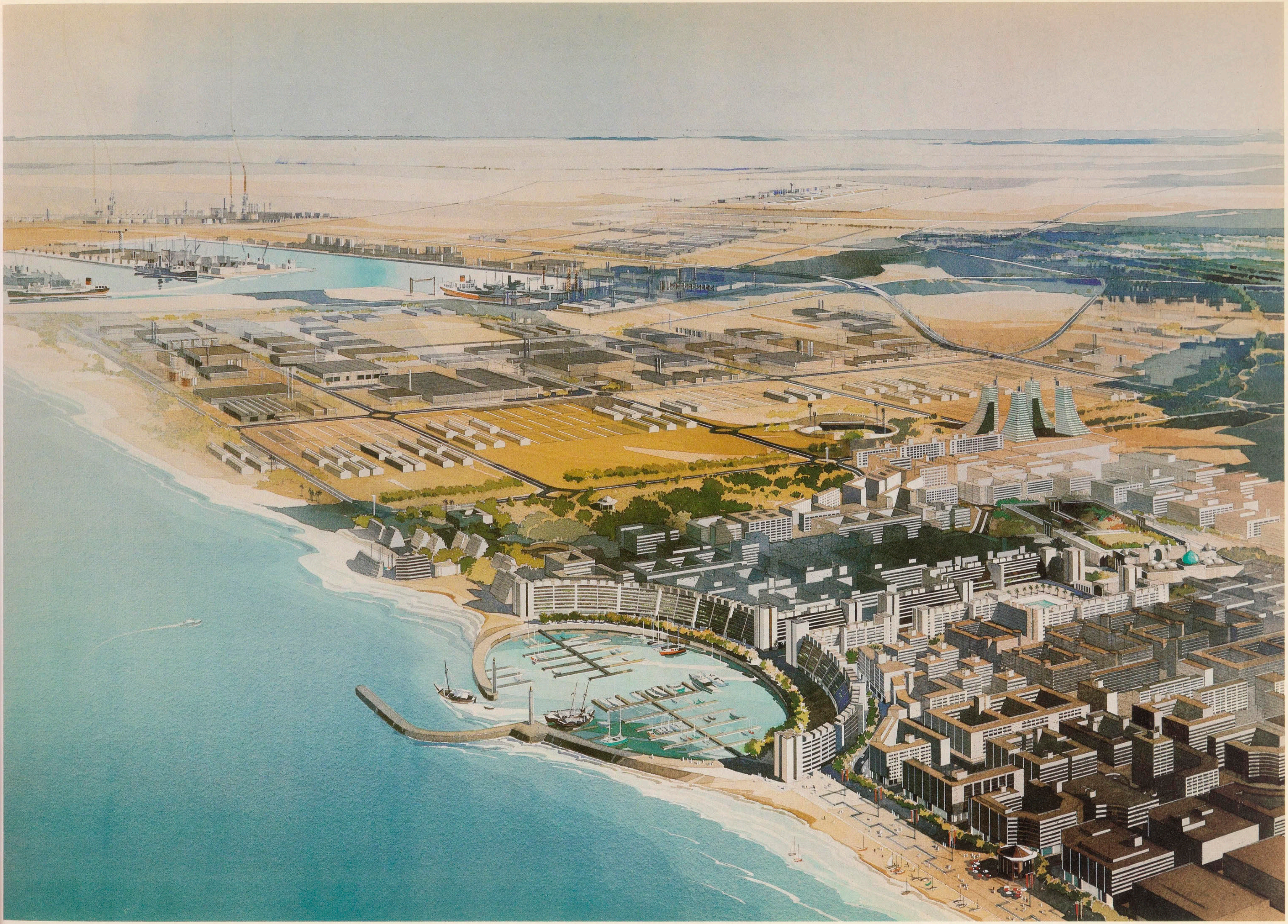
In determining the size of town we have assumed that there is no reserve of labour in Dubai, that trends within industry are towards greater capital intensive plants and less labour, and that the provision of the massive harbour complex and airport will require a high proportion of the industrial area to be devoted to warehousing. All this suggests that the ratio of workers to industrial area can be expected to be low and that the labour force will have a high proportion of skilled and semi-skilled labour and management staff.

It can also reasonably be argued that as Dubai is to remain the social capital for the area and Jebel Ali will be the industrial town, the activity rate (ie the number of people working out of the whole town population) will be high and the number of people employed in the service industries (school teachers, shop keepers, etc) will be reduced in proportion. The capacity of the building industry will also be a major factor determining the phased development of the town. In our calculations we have assumed a building rate of 4600 dwellings per annum.

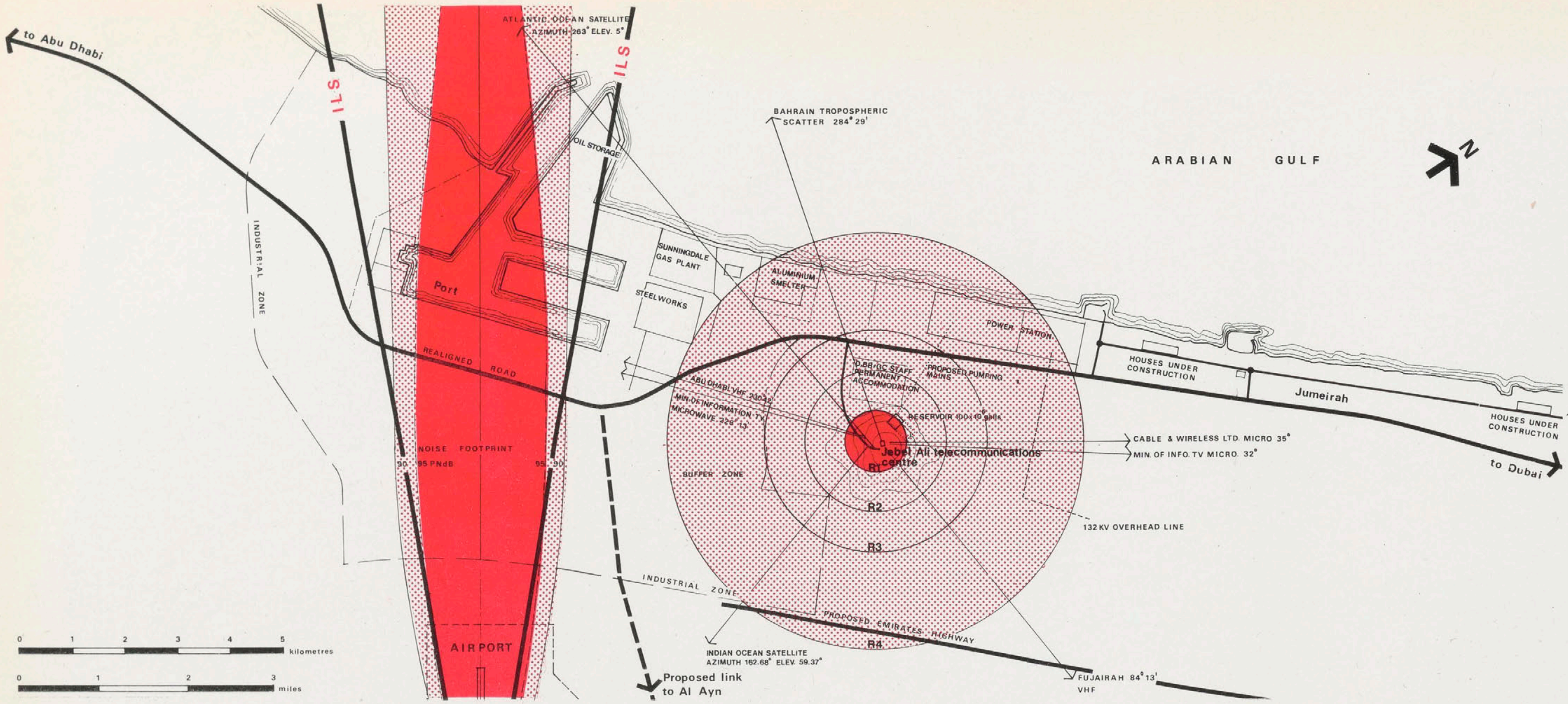
The above factors lead to the conclusion that the overall town population could reach some 529,000 by the year 2007, but should there be a predominance of single people in the town, the overall population could be reduced to 373,000. Conversely, if the industries who locate there are labour intensive and if more workers bring their families to live at Jebel Ali, then the ultimate size of the town could be as high as 758,000 We feel that it is unlikely that these conditions will obtain.

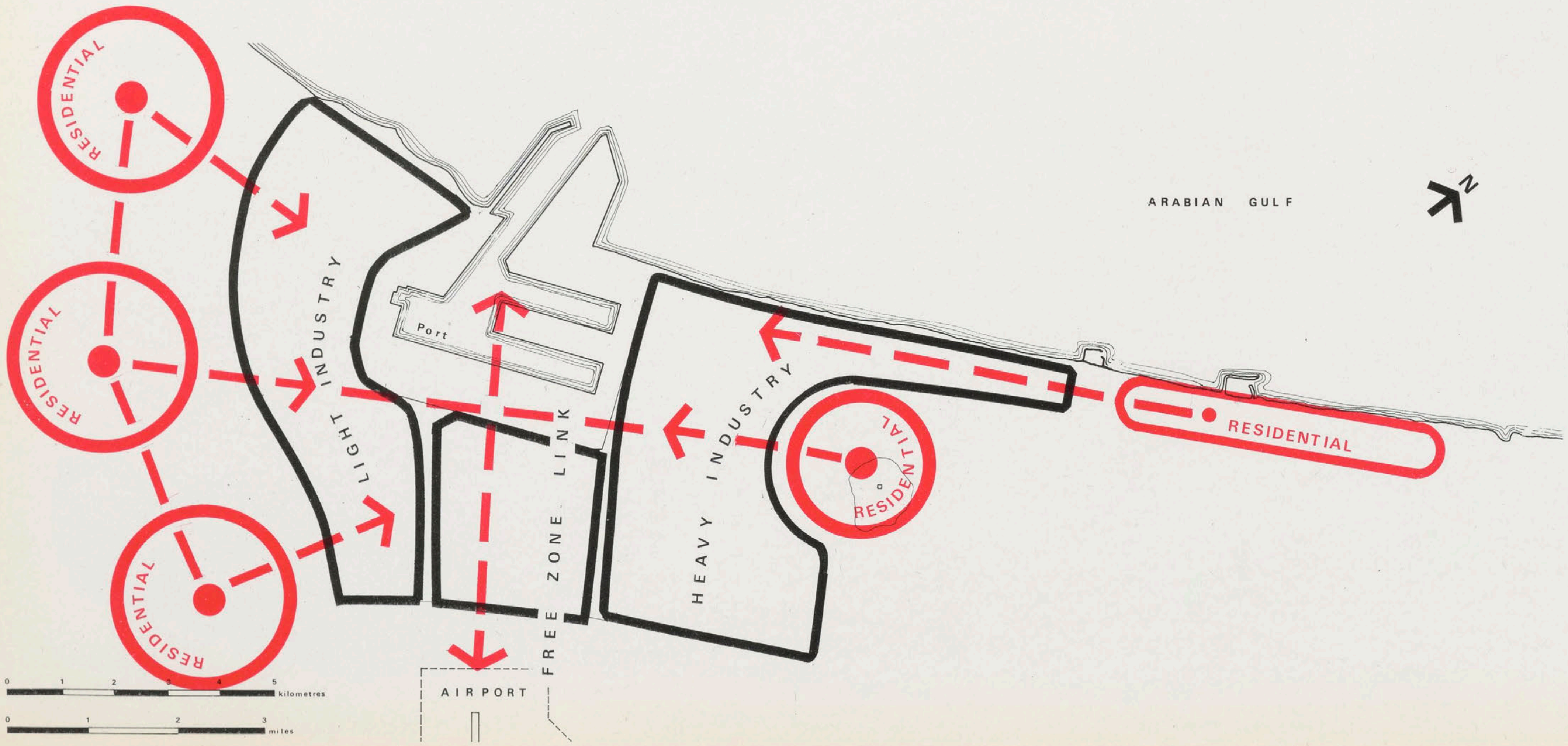
In response to the middle range of population estimates, we have prepared a concept which must be regarded as a framework for growth. Proposals are formulated for the steady and progressive development of the town in phases; each phase in isolation will have a beneficial result, being largely self-contained, so that if no further development took place each would be self-sufficient, but taking all of the phases together their effect will be considerable, as collectively they provide for the continued expansion of the town to a comprehensive pattern.

An immediate start must be made on the town centre, comprising part of the first phase of the town, if adequate facilities are to be provided for the first part of the industrial and port complex programmed to come into operation in 1981. The importance of Jumeirah, an attractive coastal strip between Jebel Ali and Dubai, must not be underestimated. Proposals are well advanced to build further residential estates, another marina and an hotel, and many people working at Jebel Ali can be expected to take accommodation in those houses that are within reasonable travelling distance of the new town. If Jumeirah was allowed to overdevelop then the effects could be harmful to both Jebel Ali and Dubai, as many of the advantages in both social and financial terms of a concentrated development would be lost. Yet the advanced proposals to build houses at Jumeirah could play a vital role in meeting the initial demands from the construction industry.



4 Constraints





Appraisal

Constraints

There are important physical and climatic conditions at Jebel Ali that must considerably influence the development of the Master Plan for the new town, figure 4.

Terrain

With the exception of the area around the Jebel Ali hill the site offers equal problems and opportunities to development, but a location to the west of the port provides full opportunity to maximise on the site's greatest natural attraction, the coast.

Climate

General wind direction and the nature of the atmosphere militate against the provision of housing where it could suffer from industrial pollution. Wind barriers should be formed on the town's periphery and maximum shade created wherever possible.

Airport

Neither housing nor labour intensive industry should be located beneath the area covered by the noise footprint.

The 95 PNdB noise contour represents tolerable noise disturbance during the day and the 90 PNdB contour tolerable noise disturbance at night. The ILS lines define the boundaries for the localiser beam energy zone for aircraft plotting. No building or structure should be constructed with a metal roof or wall within this zone.

Telecommunication centre

Housing must not be placed within an area covered by the first circle drawn around the centre as the effects of radiation could be harmful. No high building or structure must be placed where it could interfere with the projected communications signals.

Regional roads

The existing Abu Dhabi – Dubai road and the proposed Emirates Highway together with the proposed major road link to Al Ayn, Buraymi and Oman provide excellent opportunities to tie the development into the Regional road network.

Infrastructure

Adequate water and power can be provided for the development.

Industrial area

A sufficiently large area consistent with the provision of a 75 berth port has been designated for industrial use. The large scale, highly capitalised industries will tend to locate to the east. In the centre approximating to the noise footprint and the segregated free trade road link will be the Free trade zone including main warehousing and storage areas, and the smaller and more labour intensive industries will be encouraged to locate within the western section.

Port

The port layout will provide facilities for the major industries in the east, the free trade zone to the south and the lighter industries, including the construction works for oil and gas production, in the west. The size of the port and its design will allow it to serve major new industries regardless of their location within the industrial area.

Journey to work

The longest port quay is nearly four kilometres in length, and the industrial area is some ten kilometres wide; distances which necessitate a considerable journey to work. In order to minimise the travel times it is recommended that the major residential areas should be located to the west of the industrial area. Housing along the Jumeirah coastal strip together with the small housing area close to the Jebel Ali hill, will help to meet the needs of the industrial areas located to the east of the town.

Town Centre Location

Chapter 5
The master plan

The Master Plan is conceived as a series of districts each housing 73,000 people, separated by district centres and served by a simple grid network of roads, figure 5. The town centre is located on the coast with the more expensive housing located near the sea, and the housing for the lower-income workers adjacent to the industrial zone.

The concept aims to produce tightly knit communities which inevitably involves somewhat higher residential densities. This provides a defensive enclave – that is defensive in the climatic sense – for if the town becomes over spread out, not only does it allow the desert to encroach, but it substantially increases the cost of the infrastructure. To halve the density could almost double the cost of infrastructure.

The Town Centre will be developed to a high density and a spine of lower density mixed use activities will serve the residential districts. The plan is based upon a sequence of activities related to travel. In the residential areas where inhabitants will be of modest means walking distances dictate the pattern, and the scale and form of the buildings will be one of compactness, culminating in the flat developments along the 'high street'. In the medium and higher income areas most journeys can be expected to be made by car and the demand for larger houses, gardens and greater privacy will result in low densities.

A population of some 73,000 will require its own mini town centre and inevitably the distance between the centre and most homes will be too great to walk. The level of car use to the centre will be high, and extensive car parking provision will be necessary. The District Centre has therefore been designed on the principle of a large out of town shopping centre; an attractive introverted complex surrounded by car parking areas. This is achieved by placing a green wedge through the district to allow the centre ample 'breathing space'. Within the wedge major educational, health and recreational facilities are located. An additional advantage of this principle is that some pressure will be taken off the Town Centre that might otherwise cause undue congestion.

It is intended that the town should be constructed in phases to respond to the changing needs of the new port, the airport and the industrial complex. The first stage is located on the coast and will comprise a substantial section of the Town Centre. The overall concept provides a framework for the growth and progressive development of the town, where each phase can be self contained and self sufficient, but collectively these units will cater for all the needs of a comprehensively planned and thriving community.

5
Master plan

The master plan provides a framework for the growth and progressive development of the town.

major road network

landscape buffer zone

■ secondary school

E college of further education

H hospital

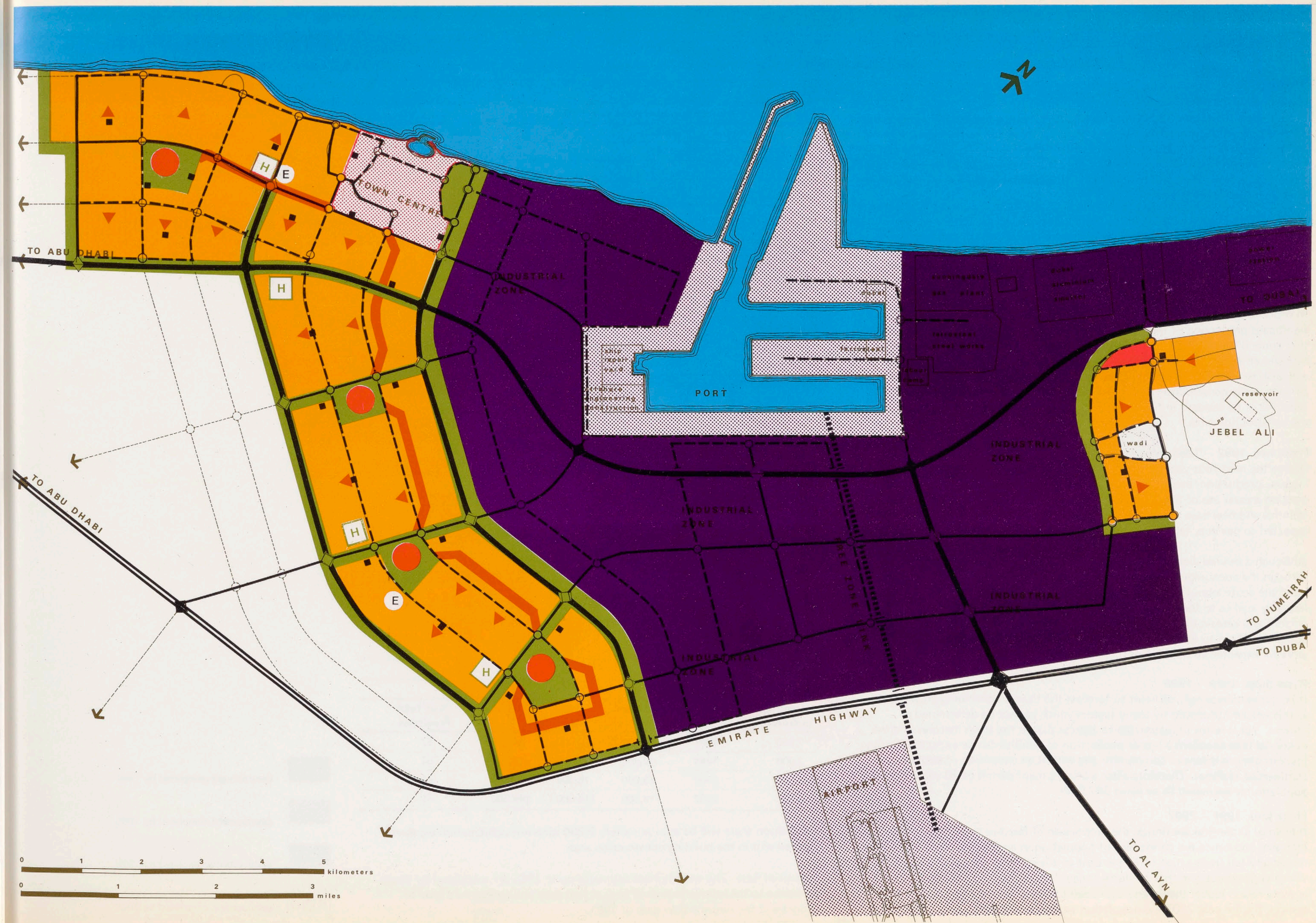
Town Centre

District Centre

Neighbourhood Centre

employment site

residential



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INDUSTRIAL ZONE
PORT
JEBEL ALI
reservoir
wadi
TO DUBAI
TO JUMEIRAH
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
0 1 2 3 miles

6
Development phases

Phasing

Phase one 1976/1981

In four years time some 19,500 workers, table 2, will be required to operate the port, airport and committed industries. Many of these will be managers, foremen and skilled workers. Other key workers will also be needed. These people can be regarded as permanent in the sense that they will not be replaced by others within a two year period. They will require high living standards and many may wish to have their families with them.

In addition to people working in the basic industries, about 13,000 will be employed in the service industries generated by the resident population, such as shopkeepers, taxi drivers, doctors, teachers, whilst others will operate the town's water supply and look after drainage and the power supply. Some of these will also wish to have their families living at Jebel Ali.

In order to arrive at a potential residential population we have assumed that a significant proportion of the workers will be single, table 3. But notwithstanding this, some 67,000 people could require accommodation by 1981. This figure includes an allowance for those construction workers and their families who will wish to settle in the new community. Although a significant number of single persons in the construction industry are expected to either commute to Jebel Ali or be resident in hostels and other accommodation which is adjacent to the construction sites.

Phase two 1982 – 1985

During the next four year period the existing industry will consolidate and increase production; inevitably there will be an increase in the volume of trade creating greater use of the port and airport and requiring additional storage facilities and new base industries; light industries and service industries can be expected to develop, tables 2 and 4.

Although a desired aim should be the achievement of a balanced community through the encouragement of more families, the nature of the proposed industrial base, the acute labour shortage plus the itinerant nature of the construction industry lead us to the conclusion that the ratio of single persons to married persons will remain high, table 3. Even so, the overall population of the town could have risen to 160,000 by 1985. This figure excludes those construction workers expected to be resident on or adjacent to construction sites.

Phase three 1986 – 1996

It becomes increasingly difficult to forecast the town's continuing growth rate, as this will be influenced by many factors which cannot be determined at present. Yet it is not unreasonable to assume that as the town matures and the industrial base broadens a higher proportion of families can be expected, leading towards a more balanced community and with it an expansion of social and commercial facilities. Therefore after a development period of 20 years the town's population is estimated to be some 347,000.

Phase four 1997 – 2007

Industrial expansion continues; the proportion of families to single workers increases and hence the percentage of population in employment will marginally fall from a high of 53 per cent to a level of 46 per cent; a figure which approximates to that of Dubai today. It is relevant to note that this activity rate is higher than many European towns where 30–35 per cent is typical. By the year 2007 the population would be 529,000.

Table 1

Population growth forecasts – Jebel Ali to year 2007

Date	Population
1981	67,000
1985	160,000
1996	347,000
2007	529,000

Table 2

Employment	1981	1985
Industry		
Port & airport	6,500	13,100
Heavy industry	3,000	3,000
Oil & petrochemicals	3,000	8,500
Public utilities	2,000	5,000
Light industry & warehousing	5,000	20,000
Total	**19,500**	**49,600**

Table 3

The Proportions of single person immigrant population and family population, 1981 to 2007

Date	Single Person Population		Family Population	
	Number	% of total population	Number	% of total population
1981	22,000	33	45,000	67
1985	55,000	34	105,000	66
1996	102,000	29	245,000	71
2007	128,000	24	401,000	76

Although the proportion of single person immigrant population is predicted to fall, the socio-economic composition of the total population exhibits small changes.

Table 4

Employment – Medium range

Construction Industry	Date	Industrial Base	Service Base	Total	% of Total Population
2,000	1981	19,500	13,000	34,500	52
2,000	1985	49,600	33,000	84,600	53
2,000	1996	93,000	76,000	171,000	49
2,000	2007	119,500	119,500	241,000	46

In addition there will be approximately 9,000 itinerant construction workers located within the building construction area.

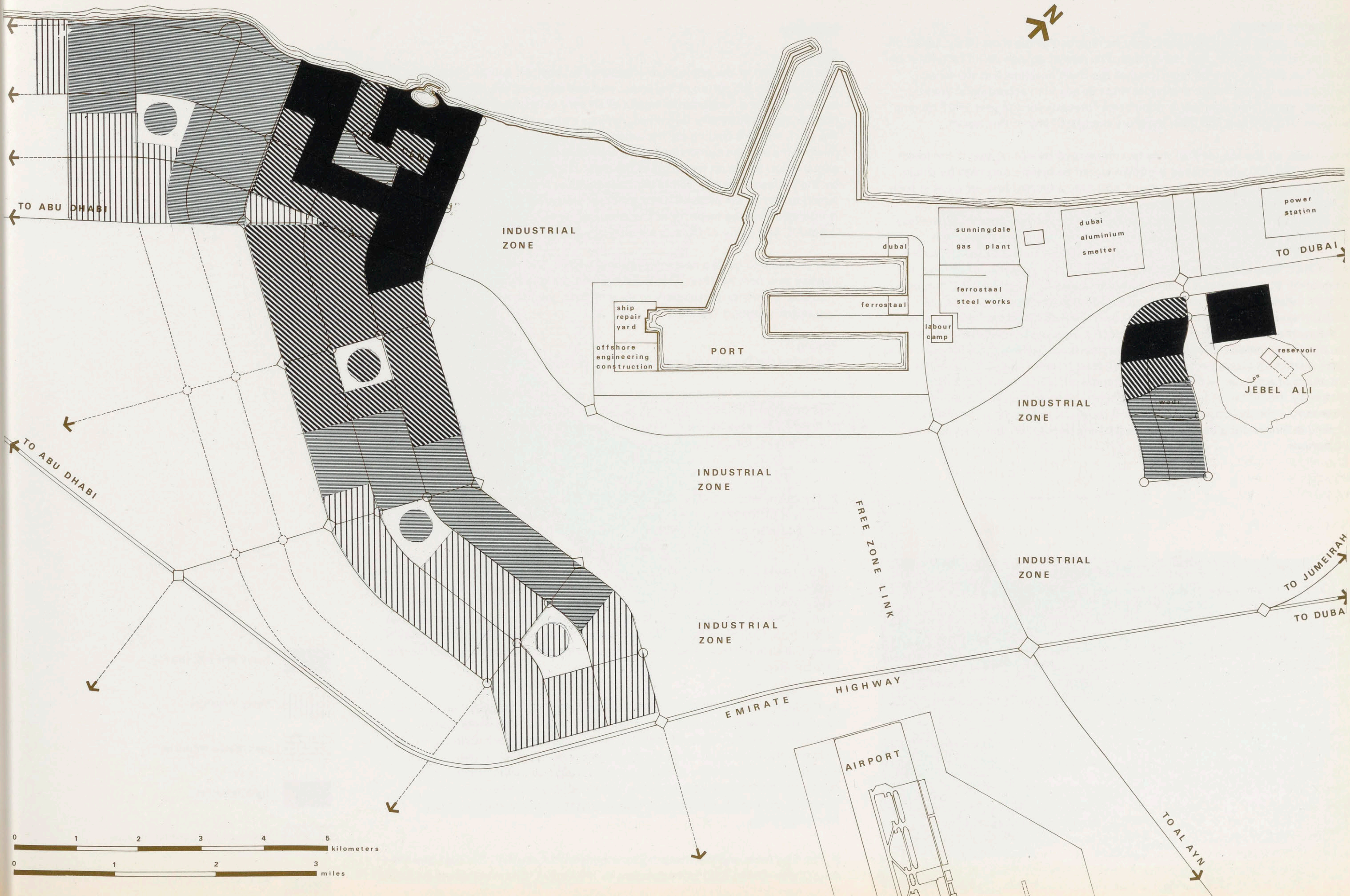
Industrial Base: The employment estimates up to 1985 are calculated by direct reference to the known industrial base at that date and an assumed level of progress at the intermediate date of 1981.

development completed by 1981

development completed by 1985

development completed by 1996

development completed by 2007



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PORT
ship repair yard
offshore engineering construction
dubal
ferrostaal
labour camp
sunningdale gas plant
ferrostaal steel works
dubai aluminium smelter
power station
TO DUBAI
reservoir
JEBEL ALI
wadi
INDUSTRIAL ZONE
INDUSTRIAL ZONE
FREE ZONE LINK
INDUSTRIAL ZONE
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TO ABU DHABI
TO JUMEIRAH
TO DUBAI
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
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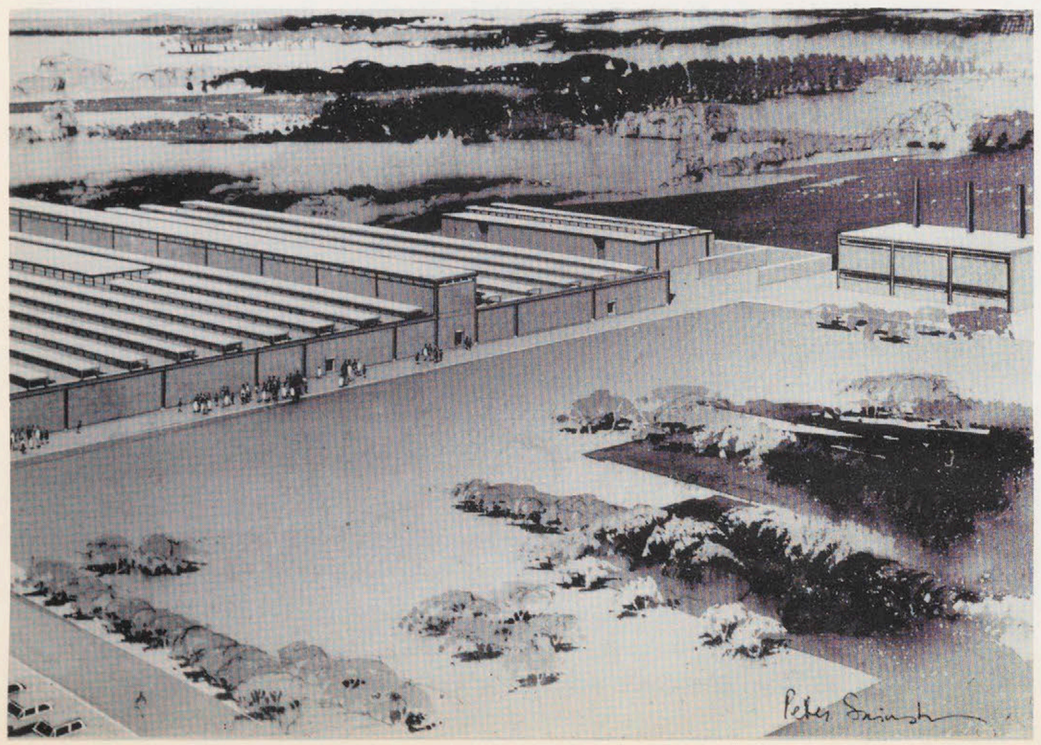
7
Industrial zones

Alternative forecasts
The above target population levels may be regarded as the most likely, based on the limited information that is available. The rate of growth could be greater or slower but this can only be monitored as the town develops and the service facilities and infrastructure provisions must be adjusted accordingly. We have, however, considered alternative population forecasts for the year 2007 ranging between 373,000 and 758,000; these are discussed later in this report.

The effects on the Master Plan may be summarised by noting that if the lower figure of 373,000 was achieved the town would be mainly occupied by single workers – an extremely unlikely event, and only a limited level of services such as schools, health clinics, play areas and to some extent shopping would be required. The residential areas would clearly be to a higher density of dwelling units and the town would extend up to that indicated in the Phase three Master Plan. Though again highly unlikely, a higher estimate of three-quarters of a million people must be considered. This higher population arises from the assumption that a greater number of workers bring their families; the number of basic industrial jobs remains the same, although a higher rate of service industry would arise. In this event, the town would expand to cover the area to the west of the town defined by the dotted lines of the main road framework. The effect on amenity and social facilities; the shopping and other services in the town, district and local centres and on the road framework would necessitate a relocation of activities within the main framework. Chapter 11 suggests that machinery should be set up for monitoring the changes that will undoubtedly occur during the development period and make the necessary adjustments. Appendix B provides a detailed appraisal of the population and employment projections.



Industry

General
The attraction of the appropriate industries to Jebel Ali will be of crucial importance to the future of the town, and will not only determine its growth, but will also be a fundamental aspect of its very existence and its future prosperity. Traditionally Dubai has played a major role in the trading scene in the Gulf, and this trading ability, aided by the business acumen of the country's inhabitants was the cornerstone of its economy prior to the discovery and exploitation of the oil resources in the area. The wealth which has been created by the oil resources now forms the financial base for a substantial investment aimed to secure the establishment of major industrial enterprises in the area. It is intended that the majority of the emirates' new industries will be located at Jebel Ali, and many of Dubai's existing industries will be re-located there.

The proposal to build a new international airport, and the commencement of massive new port facilities largely determined the general location of the various industrial elements, particularly in view of their need to be closely related to the two major transport facilities.

Zoning
The industries fall into six main categories as follows:

1 The heavy base industries located on the coastline immediately to the east of the port and to the north of the Abu Dhabi–Dubai road. Prior to the compilation of this report, sites for major industries had already been allocated in this area – the gas works, the steel works, the aluminium smelter complex and the power station.

2 The heavy and pollutive industries are located away from the town in an area south-east of the port and extending to the lower slopes of the Jebel Ali hill. Such industries are capital intensive where employment is invariably low.

3 Port based and heavy non-pollutive industries are located immediately to the west of the port. New industries in this area should be compatible with their near neighbour the Town Centre. A motor vehicle assembly factory would, for example, be appropriate; it would enjoy the benefits of easy access of supplies to and from the port on one side, and labour on the other from the residential areas. Sites for offshore engineering construction works are located within the harbour area.

4 The light industrial area marches alongside the main residential areas. This location was selected as light industrial activity is invariably more labour intensive than other forms of industry, and it was considered desirable to minimise the journey to work for the largest concentration of the town's workforce. Light industry is also the most suitable to locate near or within residential districts, typical activities being electronic and component assembly, packaging, electrical workshops, light machinery, sheet metal fabrications etc.

5 The free trade and warehousing zone lying to the south of the port and the Abu Dhabi–Dubai road and extending to the airport. The zone would be linked to the port and airport by a totally segregated road link, and surrounded by

heavy base industries

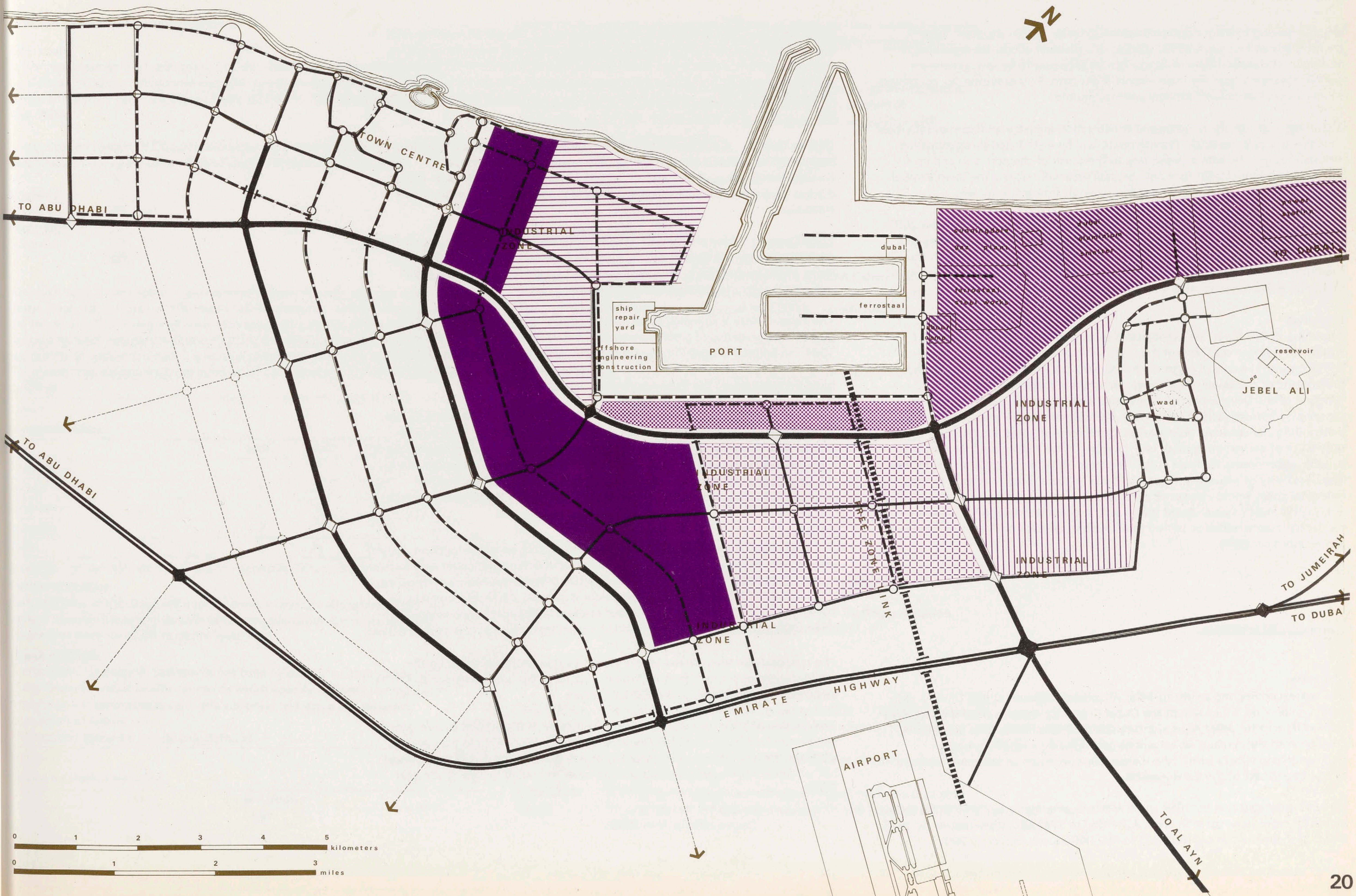
heavy industries

port related industries

light industries

free trade and warehousing zone

port related bulk storage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TO JUMEIRAH
TO DUBAI
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
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suitable fencing to form a customs controlled area. Within the zone, large transit sheds will be required for storage of individual goods, for repacking or assembly. The general level of labour can be expected to be low, consistent with its location under the main airport flight path. Full provision for containers pallets and roll-on roll-off services will be required.

6 Storage areas for the building and construction industry with low employment densities and bulk transport requirements, will be distributed throughout the industrial zone. The area immediately to the south of the port area and up to the realigned Abu—Dhabi road area be used especially during the town's initial development, as a gathering ground for materials brought in by sea.

The total area of land allocated for the six industrial zones up to the year 2007 is 5,420 hectares with an expansion potential up to the emirates highway of a further 1,020 hectares. The size of the industrial zone is consistent with the provision of a 75 berth port and international airport and the volume of industrial and storage activity that this could generate.

Incentives

Elsewhere in this report we emphasise the need to establish a Development Agency to monitor and control the town's evolution to ensure a degree of conformity to the overall concept. As industry is such a vital adjunct to and prerequisite of the town's residential element it is suggested that a prime function of the Development Agency would be to provide a service for prospective industrialists to assist their establishment in the area and to provide a marketing and servicing organisation. Consideration must also be given to the possibility of constructing small unit factories in the light industrial area, and suitable warehousing facilities in the free trade zone to attract firms to the area. The possibility of providing housing within the town directly related to the industrial space would also prove a valuable incentive to prospective industrialists, although it must be emphasised that it would be undesirable to locate any residential accommodation within the industrial area for both environmental and economic reasons.

Commercial activities

Shopping

The nearest competing centre to Jebel Ali existing today is Dubai/Deira, a twin retail complex on either side of the Dubai Creek. Its distance from the proposed residential area for Jebel Ali is approximately 35 kilometres. This distance, coupled with the demand which will be generated by a rapidly growing population will clearly justify the independent provision of adequate facilities as an integral part of the development.

We have estimated that by 1981 there will be a generated need for 74,000 square metres of retail floor space in Jebel Ali; rising to 176,000 square metres by 1985; 382,000 square metres by 1996 and to 582,000 square metres by 2007.

We are proposing that this floor space should be distributed on the following basis:—

Town Centre: This centre will be the main focus for the sale of major durable goods, such as jewelery, high quality household goods and specialist goods, eg sports equipment, artifacts etc. It will also additionally perform the function of a district centre to its immediate catchment population. The centre will be characterised by the presence of large retail units typified by the departmental store.

District Centres: A number of centres will be developed to serve a catchment population of between 40 to 100,000. These centres will provide major convenience goods such as weekly food purchases — probably through super-market development; and an element of durable goods such as furniture and clothing.

Local Centres: Many smaller centres within the residential neighbourhood will normally provide the daily shopping needs eg food and drink, newspapers etc. Some of the larger local centres may well additionally include a large retail super-market as an extension to the day-to-day facilities.

The Town Centre is expected to be developed over three phases, the first 80,000 square metres of gross retail shopping space being fully occupational by 1981; an additional 60,000 square metres by 1996 and a final stage of 40,000 square metres by the year 2007. The final two stages will depend on the rate of build up achieved by the dates suggested.

The sizes of the various district centres will depend on the catchment area and will range from 10,000 square metres to 60,000 square metres. They will be phased in accordance with the development of the residential neighbourhoods. Local centres, located within the residential neighbourhoods, will all be within walking distance of the catchment population. Their size will depend on catchment area but will range from 240 square metres to 2,000 square metres.

Offices

Although Jebel Ali will remain subordinate to Dubai as an office location, central government offices may perforce be attracted to the town and could well form a major office component. The primary objective in the encouragement of office development is the diversity of employment it affords. This applies equally to both public and private sectors. We have assessed office space accordingly for three categories; government, national/international and local commercial offices.

The proposals for the distribution of the office floorspace are based on the establishment of a strong central business district in the town centre with further amounts distributed among the district centres.

The phasing of office development suggests that by 1981, 60,000 square metres will be required rising to 157,500 square metres by 1985. Should the pace of development be maintained in accordance with the planned programme almost half a million square metres of offices will have been constructed by the year 2007.

Education and community services

Education

It has been assumed that one quarter of the population of family units will be children of school attendance age. This produces estimates of 10,000 school children in 1981; 24,000 in 1985; 60,000 in 1996 and 98,000 by the year 2007.

The education system in Dubai breaks down into four stages. Forecasts have been made of the likely percentage of pupils falling within each group:

	%
Kindergarten	12
Primary	55
Preparatory	20
Secondary	13
	100

Although school sizes will be more precisely determined at detailed urban design stage, school sizes of 100 pupils for Kindergarten and 600 pupils for the remaining three categories have been assumed. Organic changes in the demand for each category will occur during the development period as the age profile of pupils increases – a normal phenomenon of new communities. For Master Plan calculations the build-up of each category has been calculated as follows:–

Table 5

Demand for schools

	1981	1985	1996	2007
Kindergarten	14	31	74	120
Primary	11	24	57	92
Preparatory	4	9	21	33
Secondary	3	6	14	22
Total	**32**	**70**	**166**	**267**

Clearly this position will have to be closely monitored as the town develops.

Further education

Requirements at this stage are imprecise but a land use allocation of two 50 hectare sites for the establishment of further education campuses has been assumed to cater for 5000 students, post 1985.

Health facilities

The demand for hospital bed spaces has been calculated in accordance with Dubai Department of Health standards which specify 3.5 beds per thousand population for general needs and one obstetric bed space per thousand population of family units.
The demand therefore can be calculated as:–

Table 6

Demand for hospital bed spaces

Year	Bed spaces
1981	290
1985	660
1996	1470
2007	2250

Based on the accepted standard of 600 bed hospitals we have assumed that one hospital will suffice until 1985, a further two by 1996 then increasing to four hospitals by the year 2007.

In addition, Health Centre requirements are being proposed on the basis of a catchment radius of 0.75 of a kilometre which implies a catchment population of 10,000. The number of centres phased in accordance with population growth then becomes:–

1981	7
1985	16
1996	35
2007	53

Other community services

Mosques

They are to be located in all District Centres and a Grand Central Mosque provided in the Town Centre complex. Smaller mosques will be located in residential neighbourhoods on the basis of 8,000 to 12,000 resident population.

Police stations

Provision has been made for one in each District centre and the Town Centre with smaller police stations in the larger Local Centres.

Fire stations

A central fire station is located in the Town Centre with a satellite sub-stations in the District Centre and industrial zone.

Meeting places/halls

Every Centre will have a meeting place ranging from the small community room to the larger halls.

Recreation and leisure facilities

The following proposals are included in the Master Plan:

Hotels: between two to four 300 to 500 room hotels, one to be built by 1981.

Cinemas: on the basis of one cinema for 80,000 – 90,000 population (1,000 seats per cinema), the requirements are:

by 1981 1
by 1985 2
by 1996 4
by 2007 6

Sports Halls: using the standard of one for every 10,000 – 12,000 population these will be located in association with schools, local and district centres.

Country Club: one to be integrated into the Town Centre recreation complex, to include a marina.

Local Open Space: in addition to general amenity space round centres a provision for one hectare per thousand population will be made within the residential neighbourhood.

Housing demand and supply

The demand for houses will be determined by the success with which industry is attracted to Jebel Ali. The availability of housing for potential resident/workers will be a strong factor in attracting industrialists. It is therefore important that there should always be a short lead time in the housing programme and other support developments; apart from the encouragement of industry in terms of supply this will also have the effect of achieving a reasonable level of stability in rental values, another important factor for the industrialist contemplating development in the town.

Apart from the quantity of houses available, the range of provision must match both the aspirations and the ability to pay of the incoming population — so often this is not the case, and the cost of housing excludes many of the lower paid workforce as a result.

In order to determine as closely as possible the composition of housing, and thus avoid the mis-match described above, an estimation of the structure of the future population that will be needed to support the levels of activity generated by new industry has been made. The following Table describes the range of competence required thus offering a basis for the determination of housing composition.

Table 7

Percentage of total population in each socio-economic group

Date	Group 1 Management, Professional & Technical	Group 2 Supervisors, Foremen, Skilled Manual & Office	Group 3 Semi and unskilled manual and Clerical
1981	17	34	49
1985	16	32	52
1996	17	29	54
2007	18	28	54

A detailed appraisal of the various house types that will be required at the phases of the town's development is given in Appendix B and is summarised as follows:—

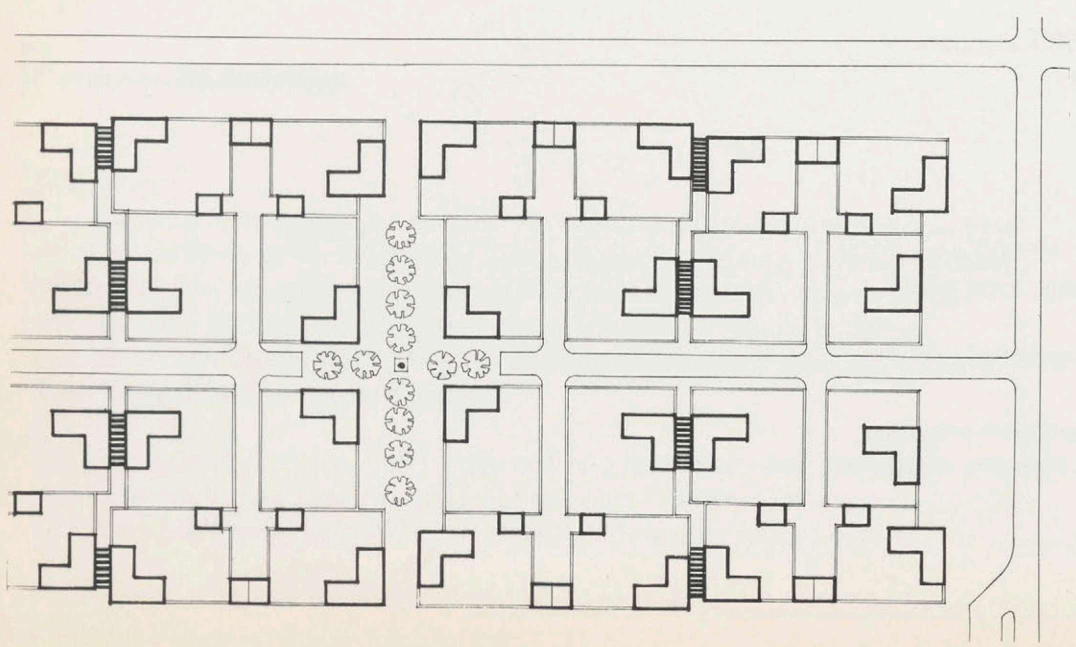
Dwelling types

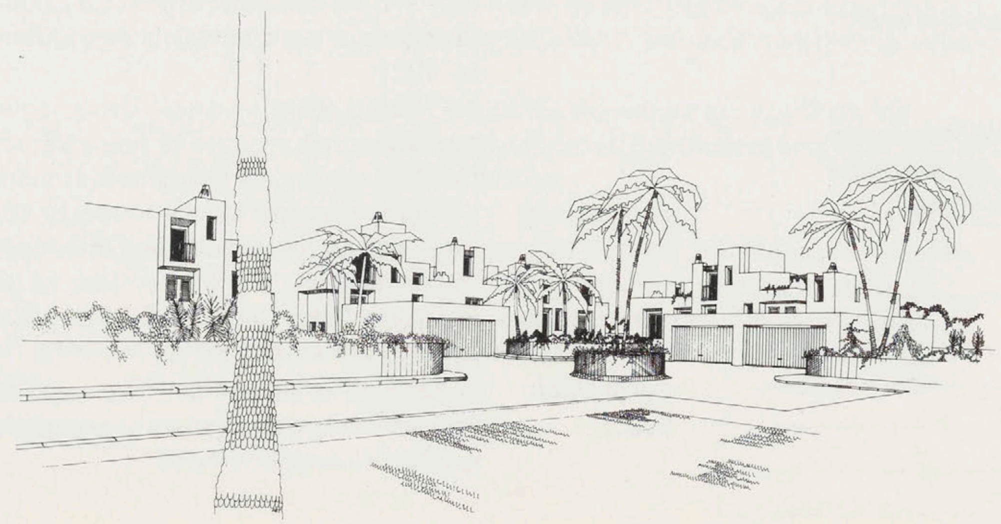
Housing type 1

This group will require the highest standard of housing both in villas and within high rise flats in the town centre.

Housing type 2

The range of dwellings suitable for this group extends from low density family houses to high rise flats in the town and district centres.





Housing type 3

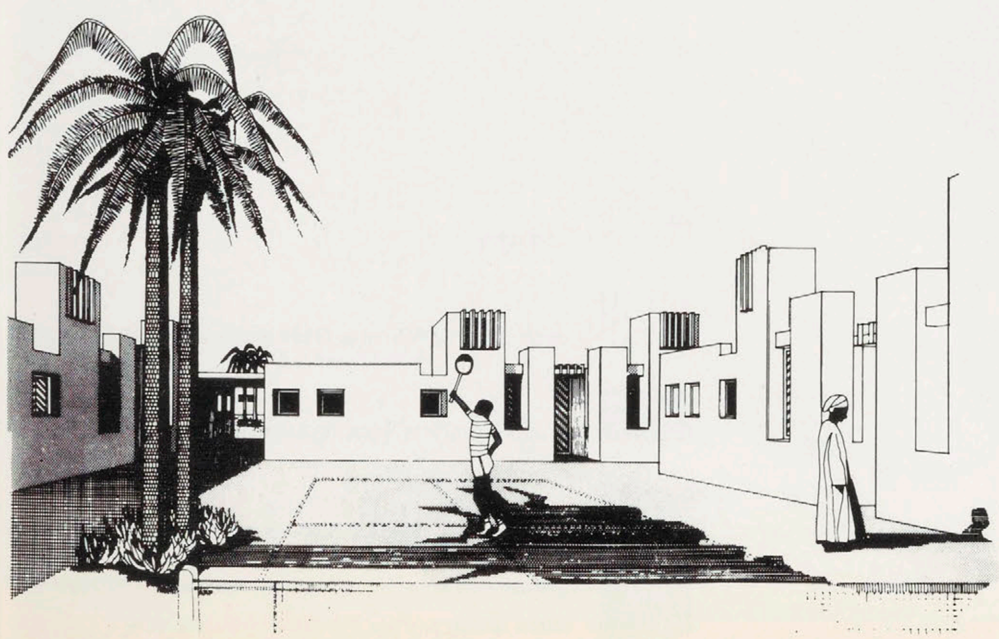
The range to be provided will extend from high density apartment blocks in the town, district and neighbourhood centres to shared dormitory units in low income residential areas.

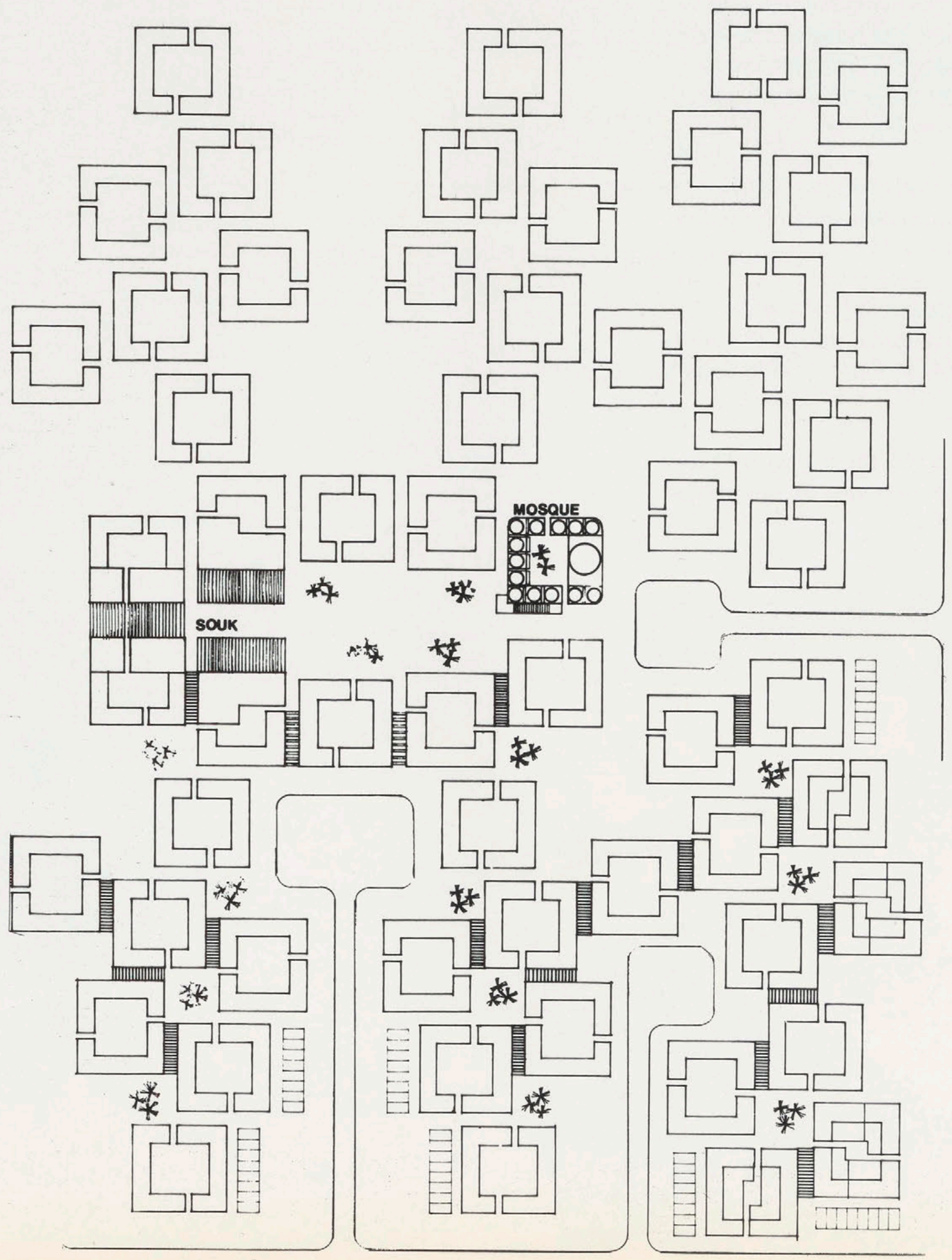
Providing for the lowest paid workers presents special problems, and we have therefore investigated this in some detail because it is anticipated that in the early years of the town's development they will form a large part of the labour force. As the town matures, the balance will change in favour of more permanent workers and a growing proportion of families.

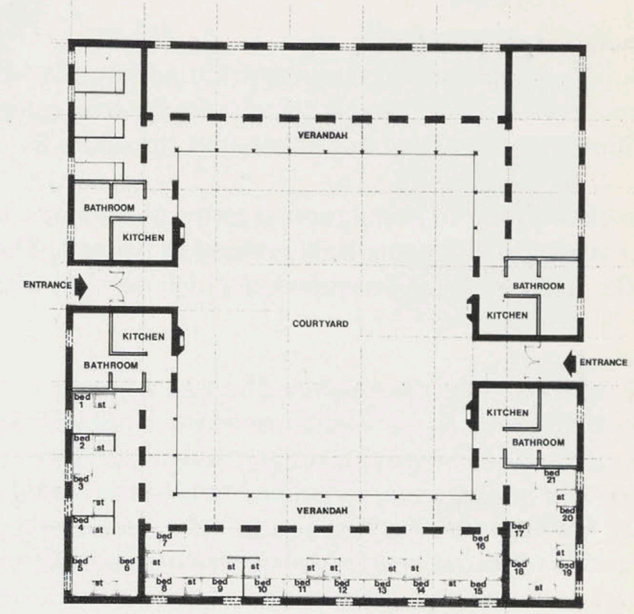
In response to this demand, a unit has been designed which would be built initially to house single workers, and would be of very low cost. This would not be of permanent construction. As the standards of living rise, and as the need for family accommodation grows, the units can be converted and improved to provide a better standard of accommodation.

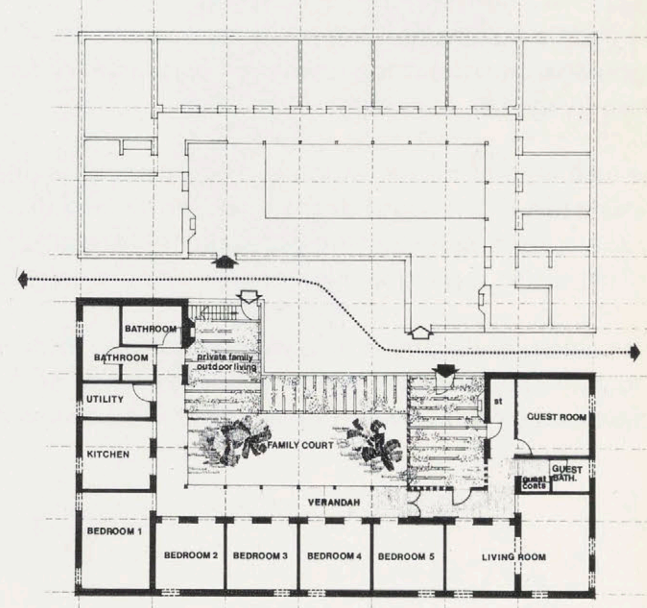
The basic plan is a square with a large courtyard in the centre. The single storey building can be laid out initially to provide either 40 bed spaces in a dormitory layout or 20 bedsitting rooms. In both cases the washing and cooking facilities are shared. This basic building can then be upgraded to provide either two large family patio houses or four medium sized family houses. The standard of upgrading can vary to suit the circumstances, or could be a gradual improvement by the occupants.

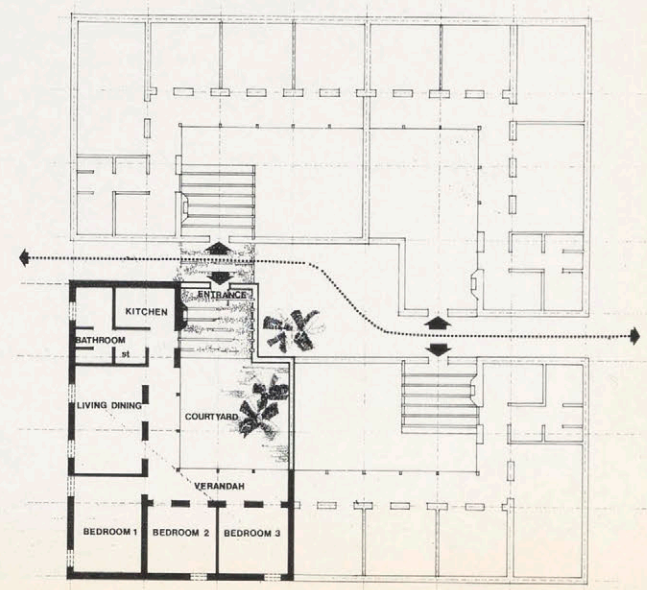
Generally this would include extra partition walls, extending power and light services, improving internal finishes, erecting garden walls and paving around the house, and the addition of air-conditioning units. The variations are illustrated below.











8
Population distribution and density

Population distribution
The housing demand has been distributed into the five main population locations within the town – town centre, district centres, neighbourhoods, Jebel Ali and also in Jumeirah. This is set out in detail in Appendix B.

The distribution of population in terms of numbers, density and location is also set out in Appendix B, illustrated in figure 8. The residential content of the town centre is developed at a high density, with most of the accommodation in high rise blocks.

The workers' housing is mainly disposed adjacent to the industrial zone. This ensures that the journey to work distance of the workers is kept down, and also helps to isolate the more important residential and commercial areas from the industry. Some 400 houses are programmed to be constructed on the Jebel Ali hill, and work has begun on the first group. The plan illustrates how the housing could be extended to form a residential neighbourhood, but the effect of possible wind blown pollution and difficult ground conditions will need to be fully investigated before a final decision is made on the suitability of this location.

The middle income housing is disposed evenly down through the town, with a concentration around the town centre. A large amount of middle income housing is also located in Jumeirah.

The high income house, which is at low density, is disposed mainly along the coastal strip to the south of the town centre, and in a strip down the outer edge of the town, furthest away from the industry. A considerable amount of high income housing is also located in Jumeirah.

This pattern of density distribution is designed to provide the correct proportions of high, middle and low income residential areas as the town grows, but its actual location may need to vary to meet changing circumstances.

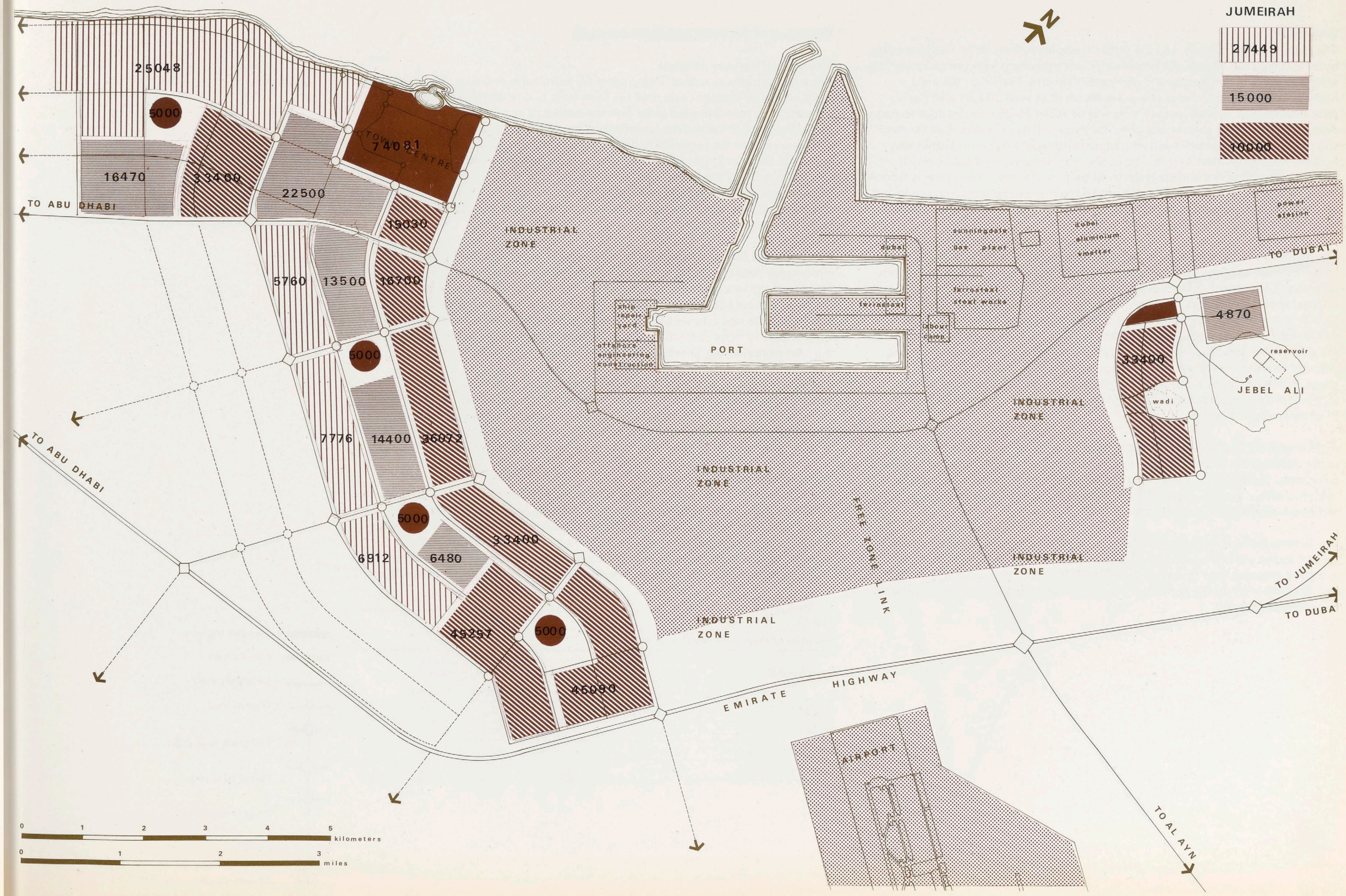
industry

high income housing areas groups I.

middle income housing areas groups 2.

low income housing areas groups 3.

high density, mixed income housing areas.


JUMEIRAH
27449
15000
10000
N
25048
5000
16470
33400
22500
7400 81
TOWN CENTRE
TO ABU DHABI
19030
5760
13500
16700
5000
7776
14400
36072
5000
6912
6480
33400
45257
5000
46090
TO ABU DHABI
INDUSTRIAL ZONE
ship repair yard
offshore engineering construction
PORT
dubal
ferrosteel
labour camp
sunningdale gas plant
ferrosteel steel works
dubai aluminium smelter
power station
TO DUBAI
4870
33400
reservoir
JEBEL ALI
wadi
INDUSTRIAL ZONE
INDUSTRIAL ZONE
FREE ZONE LINK
INDUSTRIAL ZONE
INDUSTRIAL ZONE
TO JUMEIRAH
TO DUBAI
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
0 1 2 3 miles

Chapter 6
Transport

12
Road network 2007

Summary

The main highway network and the public transport system either free enterprise, buses or a light rail system will provide efficient movement between all residential areas and the major industrial and commercial centres. Traffic on the main highways will be able to move at average speeds of at least 30 kph even during peak travel times. Typical journey time will be about 15-25 minutes door to door. Adequate parking for private cars or motor cycle will be provided at all centres, and public transport services will be frequent with boarding points within easy walking distance of most homes. The public transport system should provide a high standard of service and coverage to all parts of the city. The system is flexible, it can be introduced immediately and can be modified to accommodate changing needs. Provision has been made for new transport developments (e.g. minitram) to be introduced as they become available.

The main highway system can be adopted and expanded as the city grows. It can allow for changes in the location of development and in the intensity of land use activities. The network is hierarchical in form which means that volumes and speeds on local streets will be low whilst on the major routes volumes and speeds will be high and access strictly limited. The main shopping and commercial centres will be traffic free and networks of pedestrian paths will be provided elsewhere in the city. Within local shopping streets traffic volumes will be relatively low and required to move slowly and thus will not conflict with pedestrian activity in the street. Provision can be made for the segregation of buses, pedestrians, cyclists, etc., where local streets cross major highways. This can be achieved by the use of underpasses and bridges.

In general there is a concentration of residential population and work places in the main centres and the main activity spine running westwards from the new city centre. Industrial densities are at their highest on the western edge of the industrial area closest to the residential areas of the town. Elsewhere residential and employment densities are relatively low.

The densest traffic movements will tend to occur on the main highways running parallel to the western edge of the industrial area. The roads running into the industrial area also tend to carry high volumes of traffic. The volume of traffic and its orientation will be continually changing during the intervening years while the city is developing.

Structure of the main transport network

The regional highway network

The existing highway routes linking Jebel Ali with Dubai and Abu Dhabi are shown in figure 2. The existing coast road has been built to dual-carriageway standard. However, this road will need to be diverted eastwards away from the coast as the port develops. Firm proposals already exist for the construction of a dual-carriageway from the present Abu Dhabi/Dubai road just south of the port linking to Bayadat in the south-east. This road will skirt the northern edge of the free trade area and the airport. Although the coast road is built to a high standard the frequency of existing and proposed intersections, particularly between Jumeirah and Dubai, is such that the level of service the road would provide when heavily loaded is likely to be poor.

It is estimated that peak passenger movements between Dubai and the new airport may result in traffic flow as high as 2,000 vehicles per hour. The alignment for part of the new regional highway (called the Emirate Highway) between Abu Dhabi and Dubai has been proposed by the Municipality, figure 3. Beyond the airport and the new city we have shown the Emirate Highway running westwards to rejoin the existing coast road. A full grade-separated interchange is planned for the intersection of the Emirate Highway with the Port-Bayadat road.

A direct link would be provided from this interchange to the airport. An additional proposal for a further airport link would connect the coast road near Jumeirah with the Emirate Highway some five kilometres west of the airport interchange. Partial grade separation would be required at this intersection and also at the intersection of the Bayadat-Port road with the coast road.

The road hierarchy

The hierarchical network adopted for the Master Plan involves roads with distinctly different functions and capacities providing for different journey speeds. With regard to the study of travel demand which is described in Appendix D, we thought it appropriate to consider in detail only the main distribution roads of the network (urban motorways and limited access all-purpose roads). Within the study we adopted the following terms to describe the roads shown on the Master Plan.

Table 1

Hierarchy of roads and design specification

Road hierarchy	Specification: Type	Specification: Lanes	Design speed (Kilometres)	Lane capacity (pcu/hour)
Regional highways	Motorway	2 x 3	120	2,000
Primary distributors	Motorway	2 x 3	100	2,000
Secondary distributors	All-purpose	2 x 2	80	1,500
District distributors	All-purpose	2 x 2	60	1,000

Emirates highway
Primary road
Secondary road
District road
Full grade separation
Partial separation
Large roundabout
Others
No intersection

N
TO ABU DHABI
TOWN CENTRE
INDUSTRIAL ZONE
ship repair yard
offshore engineering construction
PORT
dubai
ferrostaal
labour camp
sunningdale gas plant
ferrostaal steel works
dubai aluminium smelter
power station
TO DUBAI
reservoir
JEBEL ALI
wadi
INDUSTRIAL ZONE
TO ABU DHABI
INDUSTRIAL ZONE
FREE ZONE LINK
INDUSTRIAL ZONE
INDUSTRIAL ZONE
TO JUMEIRAH
TO DUBAI
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
0 1 2 3 miles

13
Road network 1981

14
Road network 1985

15
Road network 1996

Both the main regional motorway (the Emirate Highway) and the primary distributors should be built to motorway standards, and will require two or three lanes in each direction. The primary distributors include the Dubai-Abu Dhabi coast road, the Port-Bayadat road and the new highway which separates the new town and the industrial area. The secondary distributors intersect the primary routes and connect the residential to the industrial areas of the town. Direct access to the secondary distributors should be strictly controlled. The district distributors lead off the secondary routes and distribute traffic within the town districts themselves. Access to these distributors is more frequent and frontage development will occur.

The primary, secondary and district roads should all be paved. This need not be the case with roads not shown on the Master Plan, namely the local streets and residential access roads. The majority of access roads could be left unpaved at least initially. They would need to be formed and compacted but a decision on more permanent paving can be left until experience in use indicates which of them need to be upgraded. Many local streets, particularly in the high density areas, will carry substantial volumes of bus traffic and these will generally need to be paved.

Typical cross-sections for each type of highway are shown in figure 16. The minimum width of paved carriageway is recommended as three and a half metres per traffic lane i.e. seven metres for a two-lane road. Roads with frontage access can be provided with a stabilised area between carriageway and buildings. The width of these stabilised strips would vary with the balance of usage between pedestrians, cyclists, animals and parked vehicles. The stabilised areas should be divided by a line of trees which would help to segregate movement and local access functions and, above all, provide welcome shade. The minimum width recommended for the central reservation of dual-carriageways is three metres. A much wider reservation is provided in the Neighbourhood High Street and this would allow for possible future provision of a segregated mass transit system in the long term. We do not see the need to provide separate lanes for buses in the first instance as the level of service of the road system should be high enough to permit buses to travel without undue delay.

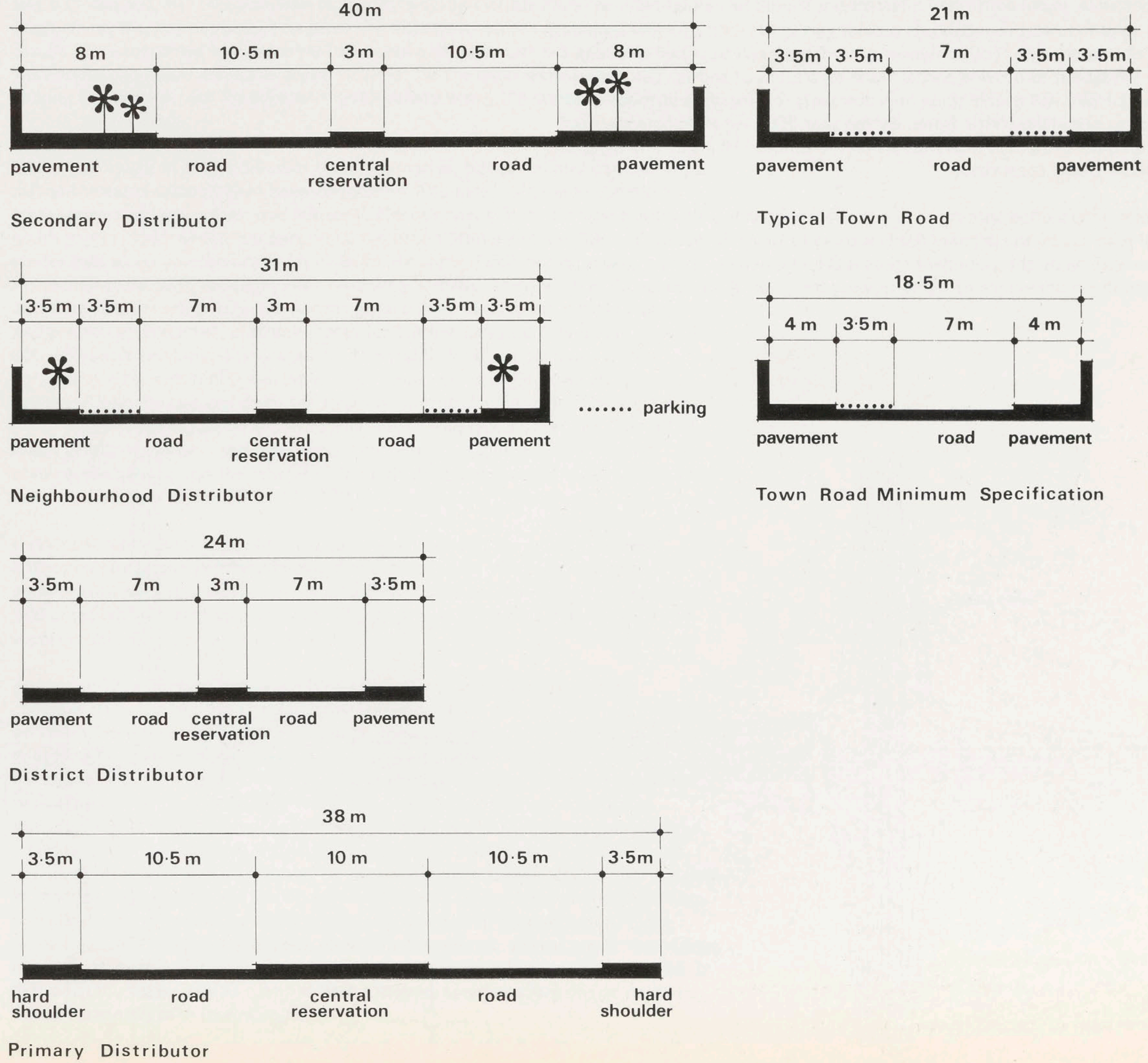
Phasing of the network

The phasing of the highway network is shown in figures 12-15. It has been assumed that the Abu Dhabi Dubai coast road will have been diverted by the end of the first stage and also that the Port Bayadat road, the new airport spur and the free zone link will have been completed by this time. The alignment of the proposed Emirate Highway has been shown on all phases although it does not form part of the Master Plan proposals.

The diagrams show the amounts of highway that need to be constructed by each date. They show how the construction of the highway network matches the development of the town centre and district centres and the residential and industrial areas. In general the construction of the highways will precede the development of the town to provide a basis for planning of other services and to provide access for construction traffic. Detailed design flows for the intersections have not been calculated for each stage but the figures suggest the form of intersections that may be appropriate.

The amount of road-space provided at each phase accords with the estimates set out in Appendix D. The phasing of the network reflects the continued growth of population and employment throughout the plan period, and the much more rapid growth of car ownership and use after 1985. At each phase work-places in the industrial areas have been located close to the town in such a way that the development of an efficient corridor public transport system is encouraged at all times.

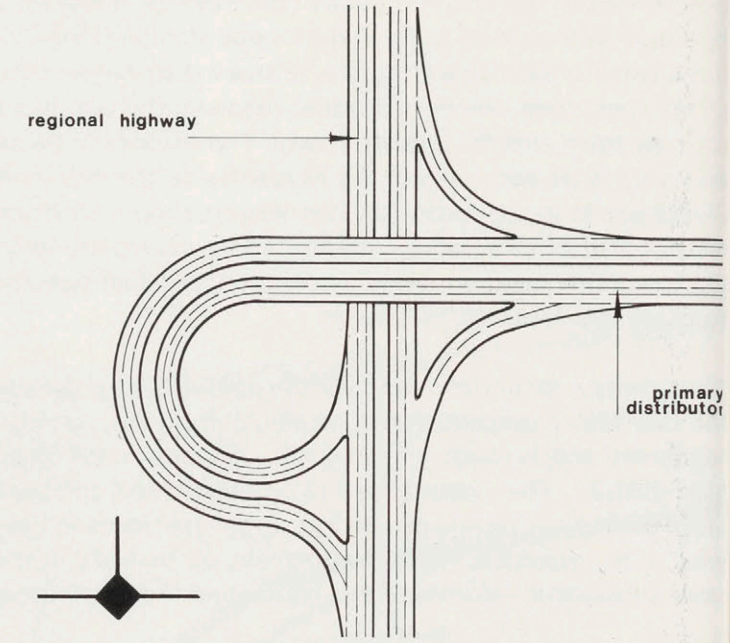
16 Typical road sections

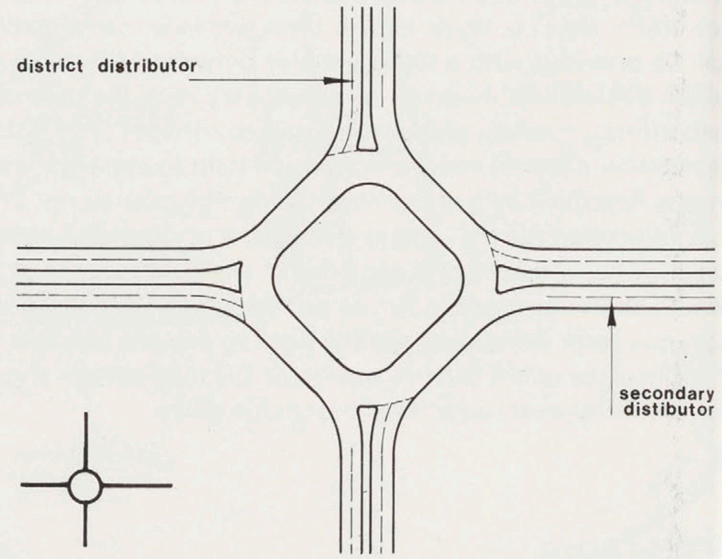


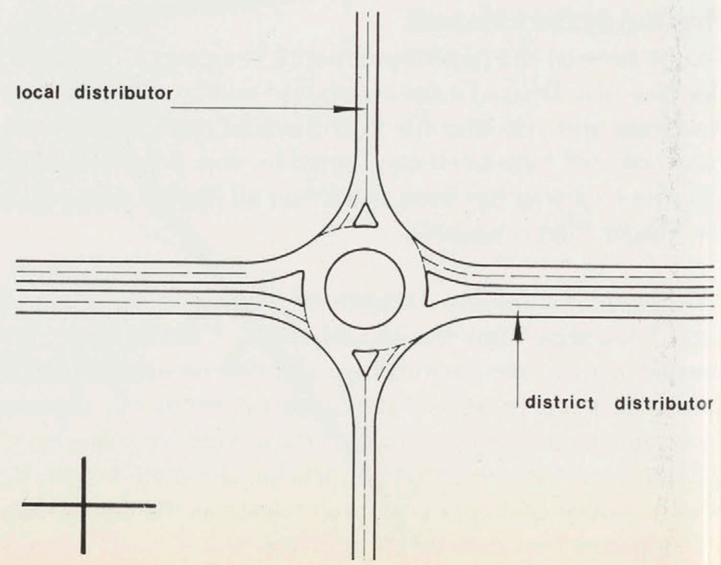
17 Typical road intersections

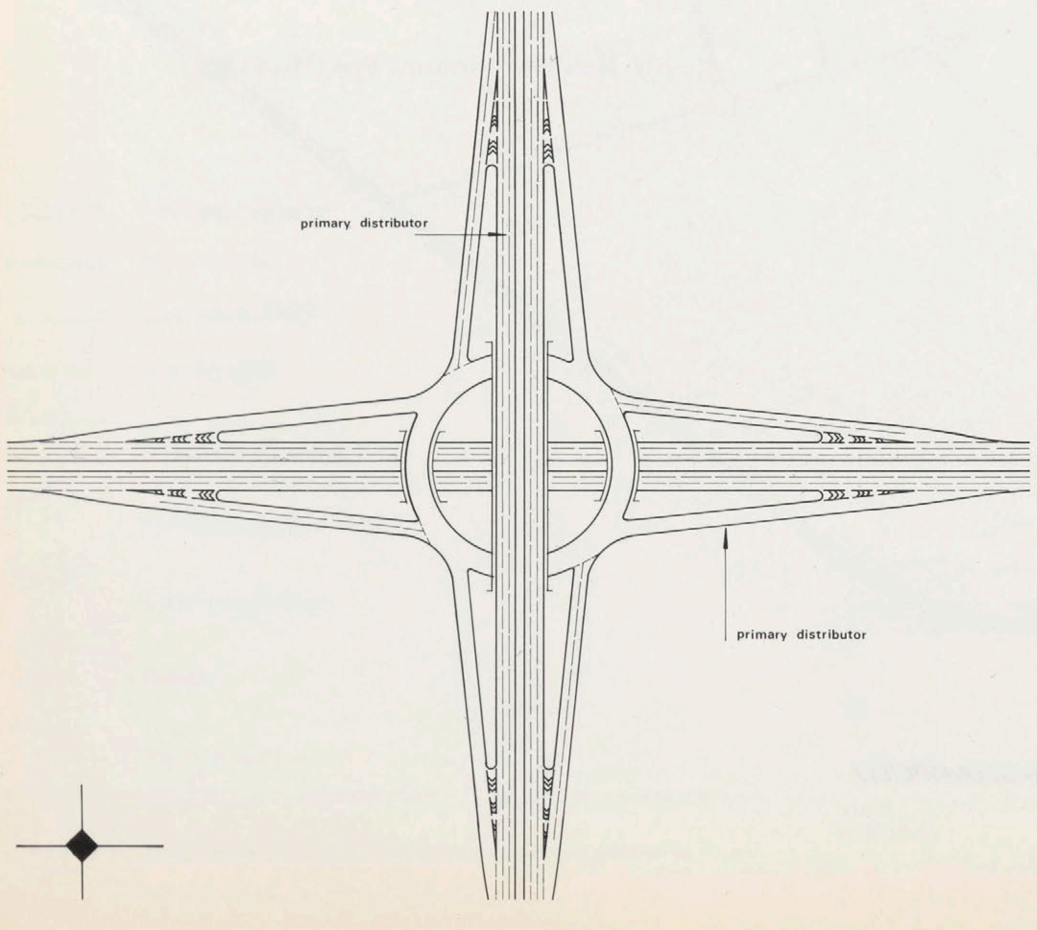
Intersections and traffic control
We recommend the general reservation of 50 metres of land adjacent to highways for environmental reasons and to provide additional rights of way for future transport systems and public utility services. In the short term, large diameter roundabouts at intersections (for which we are not able to carry out detailed design calculations) should be installed at the following sizes: intersections of two dual-carriageways on primary and secondary distributors — 60 metres diameter: intersections of district and local streets — 30 metres diameter. Typical examples of these intersection controls can be seen in figure 17. On other roads of lesser traffic importance, signal controlled intersections should be considered.
The use of large diameter roundabouts provides great flexibility for the long-term upgrading of interchanges. Thus a flyover or underpass can be added to a large diameter roundabout to provide partial grade-separation of traffic. The provision of ample rights of way will enable these improvements to take place without undue interference to prevailing traffic flows. By the year 2007 we anticipate the need for four full grade separated interchanges on the Emirate Highway and three on the Abu Dhabi Dubai coast road.

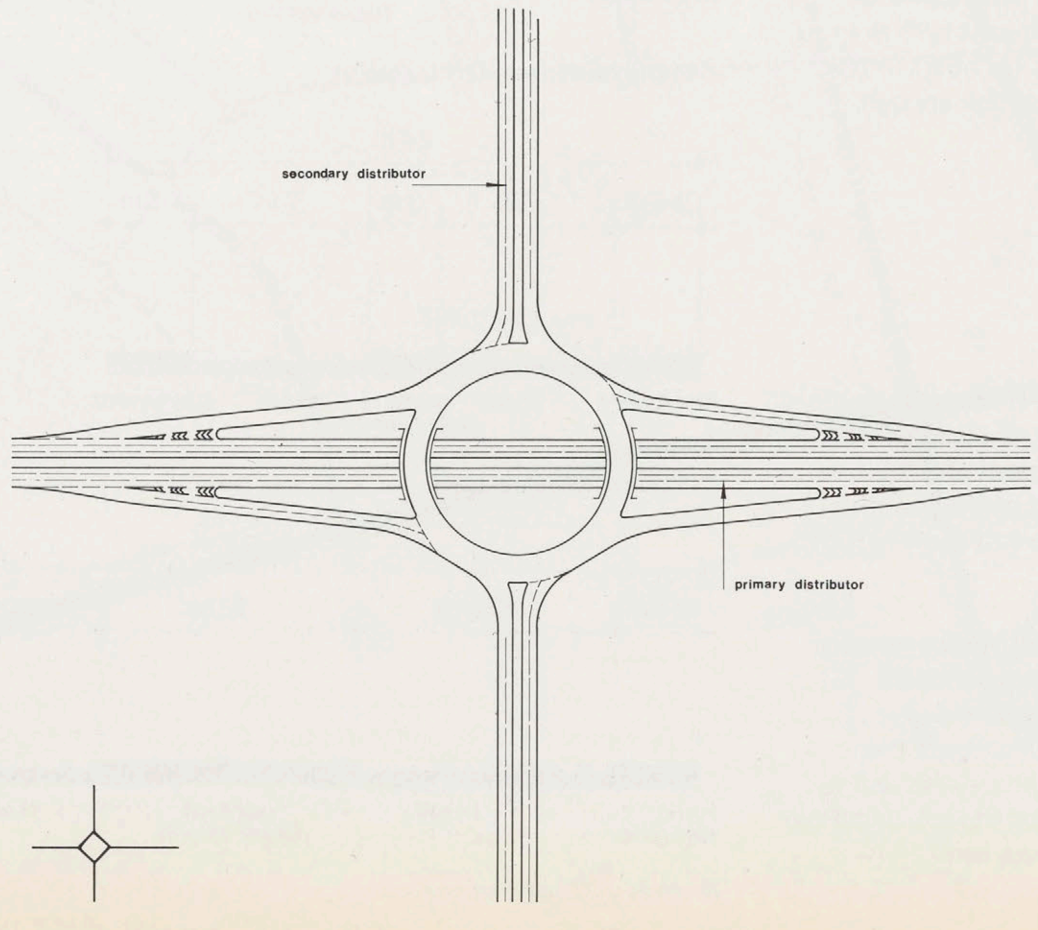
The minimum intersection spacing on the Emirate Highway is six kilometres and typical spacings on the primary roads is three to four kilometres. The average intersection spacing on the secondary roads is 0.8 kilometres. These spacings are important to the maintenance of freely-flowing traffic on these roads.











Parking facilities

In existing cities with high car ownership levels, parking has become a major land use. For Jebel Ali as both population and car ownership levels increase there will be an increasing demand for parking spaces, particularly in the town and district centre. In the new town centre where the opportunity exists to plan for the motor car in a comprehensive way, parking provision will form an integral part of the design and location of major buildings and activity centres.

We have assumed that wherever possible parking for and servicing of buildings will take place off the road within the curtilage of the building. This means that less road space is occupied by parked cars and delivery vehicles, and overall the amount of road space required is reduced. However, in many streets short-term parking at the road side has been planned for.

The overall car ownership levels average 0.9 car per household although in some areas the levels may be two or more cars per household, Appendix D. In the low density residential areas, provision can readily be made for these high ownership levels. Within the town and district centres we have adopted a parking provision standard of one car space per dwelling unit.

The vehicle parking standards we have adopted for minimum off street parking provision is set out in Table 2. These standards are consistent with our assumptions on saturation car ownership levels and choice of mode of travel. Additional provision for commuters will need to be provided in the town and district centres and in the industrial areas. Our estimates of parking space requirements are shown on the Table.

Table 2

Vehicle parking spaces required

Land use class	Unit	Town Centre	District Centre	Elsewhere
Residential	Dwelling	1	1	1 or 2
Shops	100 sq.m. of gross floor space	4.5	5.5	2.5
Offices	100 sq.m. gross floor area	0.5	3.5	3.5

Saturation car ownership levels for Jebel Ali

Socio-economic groups within the population	Average no. of cars per houshold: Family households	Single person households	Average no. of cars/head
I Managerial, professional & technical	1.4–1.8	1.0	0.40
II Supervisors, foremen, skilled manual & office staff	1.0–1.4	0.5	0.35
III Semi- & unskilled manual & clerical staff	0.6–1.0	0.25	0.20
Overall average	0.9	0.38	0.28

Public transport

The need for a basic system

The demand for travel by residents who may never own or have access to cars is sufficient for it to be essential to consider the ways and means by which this demand can be satisfied and select the most appropriate system for the future city. The main factors that influence the choice of system include capacity, power supply, service requirements and city form. We have not attempted to carry out a cost-benifit appraisal of alternative systems but, based on our estimated levels of demand, the task has been to specify a system which could be introduced gradually as the city expands. The generally dispersed nature of employment results in a widespread but relatively low volume of passenger movement to the warehouse and heavy industrial areas. However, in the main spine-corridors linking the centres, and the adjacent light industry areas, the concentration of trips is much higher.

Given the nature of this movement three alternative, but essentially complementary, public transport systems have been considered. The most suitable in the short term appears to be an urban bus network. The bus network is based on two north-south spinal routes which run parallel to the urban primary roads. The main bus routes pass along an urban corridor close to the eastern side of the main residential areas, with relatively high residential density on either side. Commercial and shopping and other high movement generating activities front these streets and provide an economic catchment area for the bus services. A two-way flow of 50 - 100 buses per hour is envisaged for this route. Most people living in this corridor will be within 500 metres of a bus stop. Since traffic flows are relatively low, the bus can share the street with other local traffic. The second north-south route would have a somewhat lower frequency of service. The other major public transport services would run east-west and serve the district commercial centres and the adjacent light industrial areas. Again bus frequencies may need to be of the order of 50 - 100 buses per hour.

Individual routes should be designed to serve all parts of the residential areas collecting passengers and distributing them to the main office and industrial areas as well as to schools and shops on a fixed schedule. A fleet of approximately 500 buses with a workforce of 1,500 - 2,000 people (including maintenance and supervision) may eventually be required.

The second system considered is a light rail system based on the minitram concept, developed by Hawker Siddeley Dynamics (U.K.) Ltd., using automatic vehicles whose speed and headways can be controlled centrally. Some technical details and a tentative layout for such a system is given in Appendix E which has been prepared with the help and advice of HSD Ltd. Trains are envisaged for peak hour operations comprising three cars each of 42 passengers maximum capacity. For practical planning purposes, flows up to 10,000 passengers per hour could be accommodated on 119 trains per hour or a half minute service. Lower line loadings than this can be served by proportionately longer service intervals but in practice many of the less loaded sections will still have a high frequency as they must deal with the return of more empty trains in a tidal flow situation. Even when frequency is matched to peak demand a five minute service can be maintained for flows of only 1,000 passengers per hour. An attractive feature of this system is that once the major capital cost has been incurred, small changes can be made to the services offered at low marginal cost.

18
Public transport

Line capacity is dependent in some respect on station capacity. On the more heavily loaded routes double platforms or so-called "D-loop" stations are necessary (these are explained in Appendix **E**). As for those routes initially using single-track working, space for station expansion should be provided where single on-line platforms are used initially where there is likelihood of increased passenger flows in the future. The small size of basic stations ensures that the space required for such expansion is small.

The operating speed of the system will be determined by factors mainly dependent upon station spacing. Closely spaced stations limit achievable maximum speeds and hence limit service speeds. At a station spacing of half a kilometre an average speed of thirty kilometres per hour can be achieved while at one kilometre spacing the service speed can exceed forty kilometres per hour, in both cases when all vehicles or trains stop at all stations. On the heavy traffic routes, where D-loop stations are used, mixed stopping and limited-stop (express) services can operate with maximum running speeds up to fifty-five kilometres per hour. It may be desirable to build D-loop stations on certain sections of route, even where the traffic requirement does not warrant them, in order to take advantage of this mixed operating capability. A detailed study would reveal the desirability of doing this in particular circumstances.

The scope for free enterprise
The third system, by contrast with a capital-intensive fixed route spinal system such as the minitram proposal described above, would rely upon entrepreneurial initiative. A fleet of publicly regulated but privately operated vehicles, ranging from motor-assisted tricycles to taxis and full-size air-conditioned coaches, and including company transport could provide in an infinitely flexible way for all those journeys that a basic system with fixed track and scheduling could not. The sole incentive for providing these services should be profit, subject to constraints. laid down by a public authority concerned with safety of the vehicles and their passengers and protection for the employees who drive them. The size of the fleet and the types of vehicles deployed would be fashioned by the pattern of demand for a whole range of services of this kind.

In major cities in many developing countries the major part of passenger transport needs is met by free enterprise services. Providing the competition is regulated by an effective licensing system and a necessary minimum of inspection and control, this can be by far the most efficient way of meeting the transport needs of the community.

The role of publicly-operated buses
This is not to suggest that a publicly operated bus service of the conventional kind is necessarily inefficient or without a proper role – on the contrary, where demand is concentrated and regularly recurring (e.g. 'corridor' flows arising out of journeys to and from work), the community can come to rely on bus services of guaranteed standard at prescribed, frequencies, timing and price. The lessons learned from the developed and long-established cities of the Western world during the late 1960's and early 1970's are instructive, as it has increasingly been realised that massive capital investment required to cater for motor cars will still not permit their unrestricted use in city centres. Consequently, planners have turned their attention instread to ensuring that adequate and reliable public transport is provided for large towns and cities. Even in America, where public transport has declined to a low level, the trend is being reversed and considerable effort and expenditure are being devoted to maintaining and improving public transport services as a preferred alternative to further massive investment in roads and car parks.

Although it is recognised that similar constraints do not operate in the Gulf and that the number and use of private cars if likely to continue increasing very rapidly in the foreseeable future, there is no certainty over the continued abundance of fuel in the long-term. Moreover, there will always be a significant proportion of the population who will neither possess, nor have access to, their own private car. These particularly include the poor, the very young, the old, and other members of families who wish to travel while the family car is in use for other purposes.

A public transport system based on buses could readily adapt to changes in population and employment throughout the planning period. If some forms of fixed track system is considered necessary then it would have to be started before 1985 to accommodate the rapid growth in captive passengers along the neighbourhood corridor. However, the existing free enterprise system and company operated transport will continue to play an important role.

Co-ordination of transport – an essential for balanced growth
Planning is therefore proceeding now on the basis that it is impracticable to concentrate all travel by one mode. The car is expected to be used increasingly (especially for leisure purposes and rather less for work purposes) in many towns and cities; but, since it is physically impossible to allow for absolutely unrestricted access by motor car in the future, new towns planned for maximum car access may experience difficulty in planning the public transport they eventually find they need.

If, on the other hand, the new town is planned with provision for a good public transport system at the outset, a much more satisfactory and balanced town structure will result with the centres more compact and all members of the community given the maximum opportunity to travel, irrespective of whether they own a car or not. The other advantages include lower levels of capital investment in motorways and other road-space and more economical use of fuel.

In order to set up public bus services, or to plan and supervise the construction of the minitram network, or to license and regulate the competition of free enterprise operations, a public transport authority needs to be established. This authority will require a clear mandate setting out its responsibilities and obligations in this important aspect of the growth and development of Jebel Ali. We recommend that this body be commissioned at the earliest possible date to consider the three related transport systems we have described.

primary corridor

secondary corridor

transport interchange

N
TO ABU DHABI
TOWN CENTRE
INDUSTRIAL ZONE
TO ABU DHABI
ship repair yard
offshore engineering construction
PORT
dubal
ferrostaal
sunningdale gas plant
ferrostaal steel works
labour camp
dubai aluminium smelter
power station
TO DUBAI
reservoir
wadi
JEBEL ALI
INDUSTRIAL ZONE
INDUSTRIAL ZONE
FREE ZONE LINK
INDUSTRIAL ZONE
INDUSTRIAL ZONE
TO JUMEIRAH
TO DUBAI
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
0 1 2 3 miles

Chapter 7
Engineering services

Water supply

General

It is proposed, as far as possible, to rely on gravity to supply water to all consumers, although the final proposals will depend on the topography and the exact location of the reservoir. A system similar to that in operation in Dubai is proposed, but modified, according to local ground levels. If possible, the Jebel Ali reservoir will be used as a balancing tank and will feed to storage tanks in the residential area, which would perferably be interconnected to provide alternative means of supply and increase the overall storage capacity in the town.

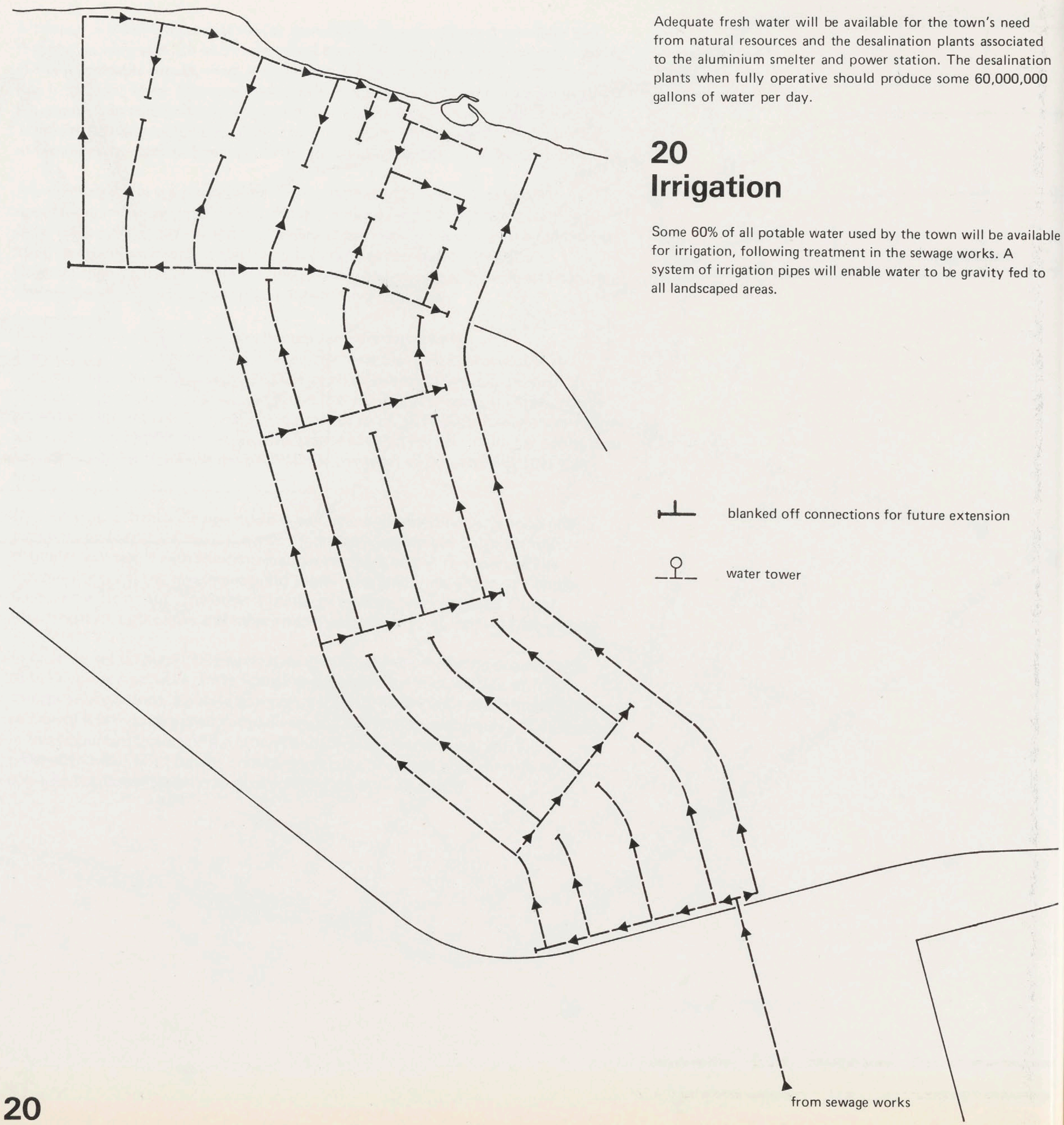
In the detailed design of the system consideration will be given to the use of overhead tower storage tanks, but the quantities of water required could mean an unacceptable number of tall structures in the residential areas. It may be necessary to provide a system of ground level storage tanks, interconnected, if possible by gravity, providing 24-hour storage each with a local smaller overhead tank to give gravity feeds to consumers. Each building would be provided with its own 24-hour storage tank, acting as a break tank to the supply.

Quantities

This report takes cognizance of the suggestions by J.D. and D.M. Watson, Consulting Engineers for Dubai, and also the State Engineer in December, 1976, to take a water consumption figure in this area of 50 gallons, per person per day. This leads to a conclusion that over the first stage of development to a population of 67,000 persons in four years, the water demand will rise to 15,300 cubic per day (3.400,000 gallons per day). The proposed main reservoir will therefore have a 10 days supply. In this initially developed area, the total storage tank capacity requirement will therefore be 15,300 cubic metres (3,400,000 gallons). Supplementary tower head tanks can be up to 450 cubic metres (100,000 gallons) capacity without being too numberous or too obtrusive. Other areas to be developed would follow this pattern.

Non-potable water

In order to conserve the maximum amount of fresh and desalinated water, effluent from the sewage works will be gravitated to the residential and industrial areas for irrigation and fire fighting purposes. It can be expected that a total of between 50 per cent and 70 per cent of all potable water used, will be available for secondary use. In the initial stage therefore, where construction use will be high, up to 4,500 cubic metres per day (1,000,000 gallons per day) would be available for the irrigation of all the landscaped areas within the town. This will continue at all stages of the development. All mains used for irrigation would be pressured from static head tanks, supplemented where necessary with reservoir ponds and mechanical plant to provide adequate quantities and pressure for fire fighting. It is essential that all mains are designed for continual flow to avoid stagnation.



20

19
Water supply

Adequate fresh water will be available for the town's need from natural resources and the desalination plants associated to the aluminium smelter and power station. The desalination plants when fully operative should produce some 60,000,000 gallons of water per day.

20
Irrigation

Some 60% of all potable water used by the town will be available for irrigation, following treatment in the sewage works. A system of irrigation pipes will enable water to be gravity fed to all landscaped areas.

blanked off connections for future extension

water tower

TO ABU DHABI
TOWN CENTRE
INDUSTRIAL ZONE
TO ABU DHABI
ship repair yard
offshore engineering construction
PORT
dubal
ferrostaal
labour camp
sunningdale gas plant
ferrostaal steel works
dubai aluminium smelter
power station
desalination plant
TO DUBAI
desalination plant
high level reservoir
JEBEL ALI
low level reservoir
wadi
INDUSTRIAL ZONE
INDUSTRIAL ZONE
FREE ZONE LINK
INDUSTRIAL ZONE
INDUSTRIAL ZONE
TO JUMEIRAH
TO DUBAI
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
0 1 2 3 miles

19

21
Sewage

The sewage system will gravitate from all areas towards the existing Abu Dhabi/Dubai Road. From this point it will be pumped to a treatment works located to the south west of the airfield and well outside any future town expansion.

Sewage disposal and waste collection

General
It is intended to locate the sewage disposal works in the same area as the refuse disposal area, thus having available the potential of a combined source of reusable water and a beneficial material obtainable from purified sewage sludge and composted refuse.

Sewage disposal
The whole of the area allocated for the township development would of necessity be the subject of detailed topographical and hydrological surveys, but pending the result of these surveys and the information on the contours and water table levels thus becoming available, it is proposed that a sewerage system will be installed gravitating as far as possible from all areas but with submersible pumps where necessary to a pumped main with pumping stations located in the industrial zone. The raw, untreated sewage would be lifted to a treatment works in an area to the south-west of the air-field and well outside any future township extensions. Provision would be made for sun-drying the treated sludge in preparation for re-cycling as agricultural compost.

During the detailed examination of any proposals for sewage treatment plant, great attention would be paid to the essential requirement to avoid obnoxious odours permeating the local environment. Liquid effluent from the sewage treatment plant would be held in reservoirs adjacent to the plant; these reservoirs would provide head tanks for any gravity reticulated irrigation system. The treatment process would be adequate to ensure sufficient disinfection appropriate to whatever use is envisaged for the effluent. It is expected that as the bulk of re-used effluent would be for municipal and amenity watering use, if subsidiary uses were required such as industrial, agricultural or horticultural, recreational or protein production, then subsidiary and additional disinfection would be required. A separate and detailed study and report would be necessary to ensure a fully co-ordinated use of effluent, both solid and liquid. Based on related figures for Dubai, it can be expected that volumes of about 160 litres per person per day (35 gallons per person per day) will reach the sewerage system. The initial phase of the Jebel Ali development will therefore require treatment works for 67,000 people or 11,000 cubic metres per day (24mgd). This size of plant would be the unit initially installed and this this unit would be multiplied as the town develops to provide an increasing capacity of treatment works related to the size of the town population.

Surface water drainage
It is recommended that precautions are taken to ensure that surface water is effectively drained away. Surface water drainage systems should be designed to avoid the risk of blockage, particularly in view of the infrequent rainfall. These systems should be simple and in many cases form part of the landscaping treatment minimising the use of extended piping systems.

The detailed planning of the surface water drainage of the Jebel Ali area must be carried out at a later stage of the development plan.

Refuse disposal
The type, amount, density and contents of refuse varies very widely and is difficult to predict accurately until a community develops its own characteristics. We have, however, made an assumption of the likely loads and these are given below. Two perameters are paramount however to achieve a disposal service which is hygienic and not obnoxious. Firstly, a frequent and clean collection service is required. Secondly, a very carefully controlled sorting, treatment and stacking system is necessary.

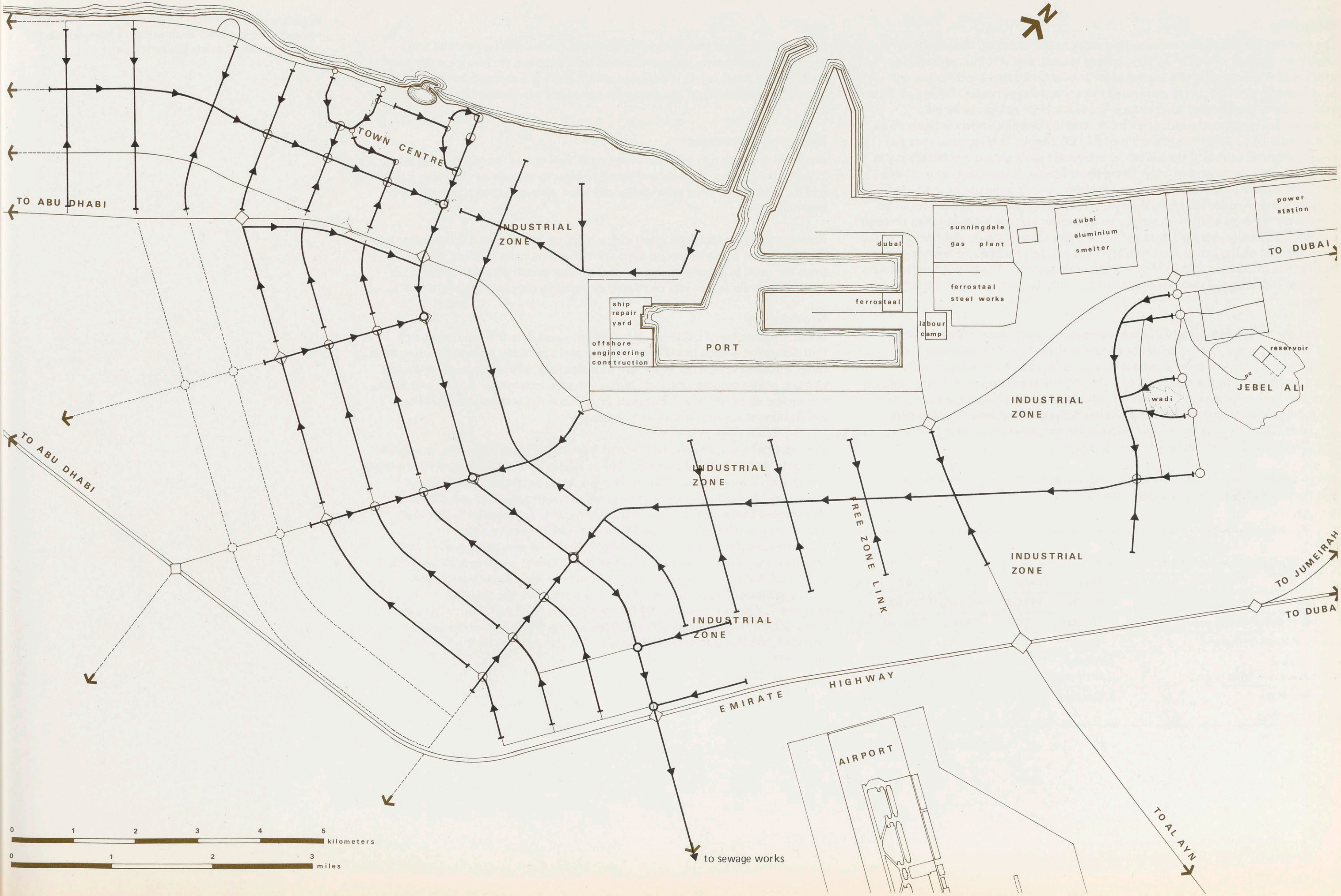
In order to obtain a preliminary impression of quantities involved, a figure of 2 kilograms (4lbs) per house per day is taken at a density of 160 kilograms per cubic metre, (10lbs per cubic feet). Relating this to the first phase of development of 67,000 persons this is equivalent to 16,000 houses and hence 190,000 kilograms per week or 32,000 kilograms per day (32 tons per day).

Taking into account the distance to the disposal area and the requirement to make collections as quickly as possible in the earlier part of the day it is anticipated that three or four medium compaction collection vehicles would be adequate for the initial stage of the town development. At the disposal works, if the study previously recommended for an overall investigation into waste re-cycling shows an economic benefit, then suitable plant would be installed. This could include provision for removing ferrous and non-ferrous metals, glass, plastic and other non bio-degradeable materials. The whole plant would be on a modular basis to provide for increased capacity in stages as the town increases.

Unwanted or untreatable materials would be taken to a remote area and tipped, under close supervision, with adequate cover to prevent an unacceptable environment developing.

General industrial wastes would be dealt with in a similar way, but probably with the use of skips or larger containers. Unusual, particular or toxic wastes would each require special and individual treatment.

blanked off connections for future extensions



N
TO ABU DHABI
TOWN CENTRE
INDUSTRIAL ZONE
ship repair yard
offshore engineering construction
PORT
dubai
ferrostaal
sunningdale gas plant
ferrostaal steel works
labour camp
dubai aluminium smelter
power station
TO DUBAI
reservoir
JEBEL ALI
wadi
INDUSTRIAL ZONE
TO ABU DHABI
INDUSTRIAL ZONE
FREE ZONE LINK
INDUSTRIAL ZONE
INDUSTRIAL ZONE
TO JUMEIRAH
TO DUBAI
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
to sewage works
0 1 2 3 4 5 kilometers
0 1 2 3 miles

Electricity

The demand for electricity varies widely from house to house, dependant very largely on whether or not an electric cooker is used, and whether packaged or window unit air conditioners are installed. It is assumed that most houses will have some form of electrically operated hot water storage heater. Taking all these into account, the installed load in each house could be as high as 30 kW. However, taking diversity into account, an average overall demand is likely to be in the order of 53 MW for a township of 67,000 people. It is assumed that the larger industrial users and the industrial estates are separate from these estimates which concern the township only. Using these figures, it is necessary to provide a 132 kV supply to the township area probably requiring the use of the two circuits to be provided in the final stages. This high voltage substation would be located on the edge of the industrial area and lower voltage supplies taken through a mains distribution network into the town areas. Depending on the final agreed configuration of the actual township layout it will be necessary to analyse the alternatives of 33 kV and 11 kV or 6.6 kV cable systems. The analyses will weigh technical and financial considerations but can only be carried out at a later design stage.

Within the Master Plan, reservations have been allocated along the motorways and other roads for electric cables or overhead lines. It will be attempted to route electric supplies underground where possible and where economically viable to conform to the standards of archietecture being provided. Compounds have also been allocated in the plan for substation areas, outside the town, in the industrial areas and within the town itself. Supply to domestic consumers will be at 380/220 volts but higher voltages for industrial consumers will be available and individual feeders to the major users.

Street lighting will be installed along all motorways and roads, with area anc and flood lighting in the municipal amenity areas.

Table 1

Population growth related to services requirements

	1981	1985	1996	2007
Population – cumulative	67,000	160,000	347,000	529,000
Number of dwelling units	16,000	42,000	78,000	139,000
Maximum electrical demand	53 MW	125 MW	270 MW	409 MW
Water demand (225 litres/day – 50 galls/day)	15,300m^3 3.4mill.galls	36,000m^3 8mill.galls	78,300m^3 17mill.galls.	120,000m^3 26mill.galls.
Domestic refuse (2 kg/house/day)	32tons/day	84tons/day	156tons/day	278tons/day

Gas

It is not anticipated that an underground gas system will be required and, apart from major users taking individual bulk supplies, no provision has been made within Jebel Ali. It is expected that if there is a demand for gas it will be met by bottled liquid gas with a private distributor located in the industrial area.

Telecommunications

A complete telecommunication system will be required for telephones, telex, T V channels, radio channels and other systems to include fire brigade, police and if necessary defence links within the town area as well as nationally and internationally.

Routes have been allocated along major road, motorways, and other roads for installation of underground systems. Areas have been reserved within the town for main telephone exchanges and smaller switching centres, the exact requirements for which will be related in detail to the planning of the E.T.C.

Fire fighting

Under the heading of utilities will be the provision of a fire fighting service. Full discussion will be based on the traditional use of fire appliances using fresh water through hose pipes. These will be supported, where necessary, by water tankers, ladder escapes, snorkles, rescue vehicles, emergency tenders and similar equipment all of which will be based in a central fire station with satellite sub-stations at appropriate areas as necessary.

In residential areas, use will be made of fresh water supply systems, to provide hydrants for fire fighting purposes, but in industrial areas a separate fire hydrant system would be provided. This system would be separately supplied and pressurised. Consideration would be given to the provision of static water tanks where the presence of a particularly hazardous substance is stored or manufactured. The whole of the fire service would have its own telecommunications system linked into the national telephone system and providing for remote alarms to a central panel. Direct communications with the Police, Military authorities, airports and between central station and mobile vehicles. This system would be integrated into the national telecommunications system. The hydrant system for larger industrial users could possibly make use of effluent from sewage treatment works as it is intended that this will be of sufficiently high standard to use for irrigation purposes.

22
Power supply

A main power supply from the power station will run to a high voltage sub-station from which will run a mains distribution network into the Districts and Town Centre.

Distribution via 6.6 KV/380 local sub-stations

N
TO ABU DHABI
TOWN CENTRE
INDUSTRIAL ZONE
ship repair yard
offshore engineering construction
PORT
dubal
ferrostaal
sunningdale gas plant
dubai aluminium smelter
ferrostaal steel works
labour camp
power station
TO DUBAI
step down sub-station
INDUSTRIAL ZONE
FREE ZONE LINK
reservoir
JEBEL ALI
wadi
40 metre infrastructure corridor
30 metre high pylons feed to Dubai
TO JUMEIRAH
TO DUBAI
EMIRATE HIGHWAY
AIRPORT
TO AL AIN
Alternative route to new town on pylons, running south and around the airport
0 1 2 3 4 5 kilometers
0 1 2 3 miles

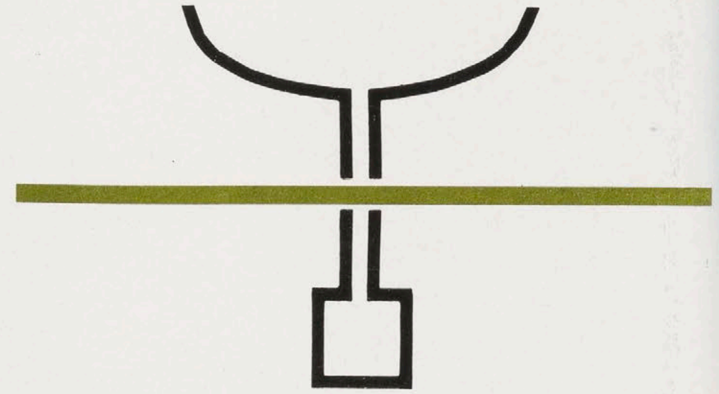
3

Chapter 8
The town centre

The need for a Centre
No solution for a town can be total. Life is too complex. Demands change quickly especially in a rapidly developing economy, yet basic needs remain. The desire to feel at the centre of things; the convenience of numerous activities within easy reach and reliance on personal contact as against the more impersonal telephone conversation, suggest that concentrated activities in a central location is likely to remain a human need as far into the future as we can reasonably plan. We have therefore designed a major Town Centre. For Jebel Ali between the sea and the existing Abu Dhabi – Dubai Road. The site takes full advantage of the areas two most important features, good communication and the splendid coastline aspect. The benefits of the cooling sea breeze in summer also argues for a coastal location.

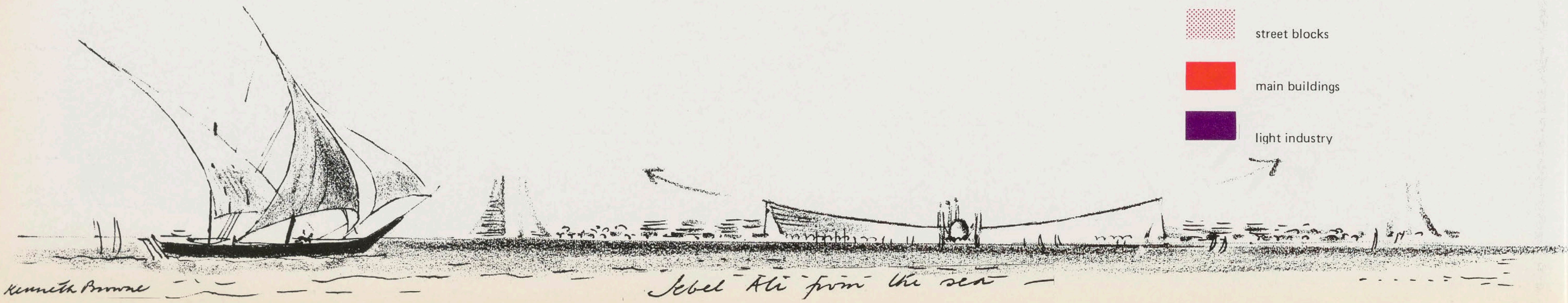
The site has another advantage, since it will remain the geographical centre of the town for many years, as it develops westward along the coast and southward alongside the industrial zone.

23
The town centre



The central core

●	water tower
1	Marina
2	Crescent
3	Boulevard
4	Rashid square
5	Avenue
6	Central mosque
7	small scale residential area, small shops and markets
8	shopping centre
9	bus taxi station
10	town park
11	sports stadium
	informal landscaping
	formal landscaping
	street blocks
	main buildings
	light industry




N
ARABIAN GULF
1
2
3
4
5
5
6
7
8
9
10
11
0 100 200 300 400 500 metres
½ kilometre
0 1000 2000 2640 feet

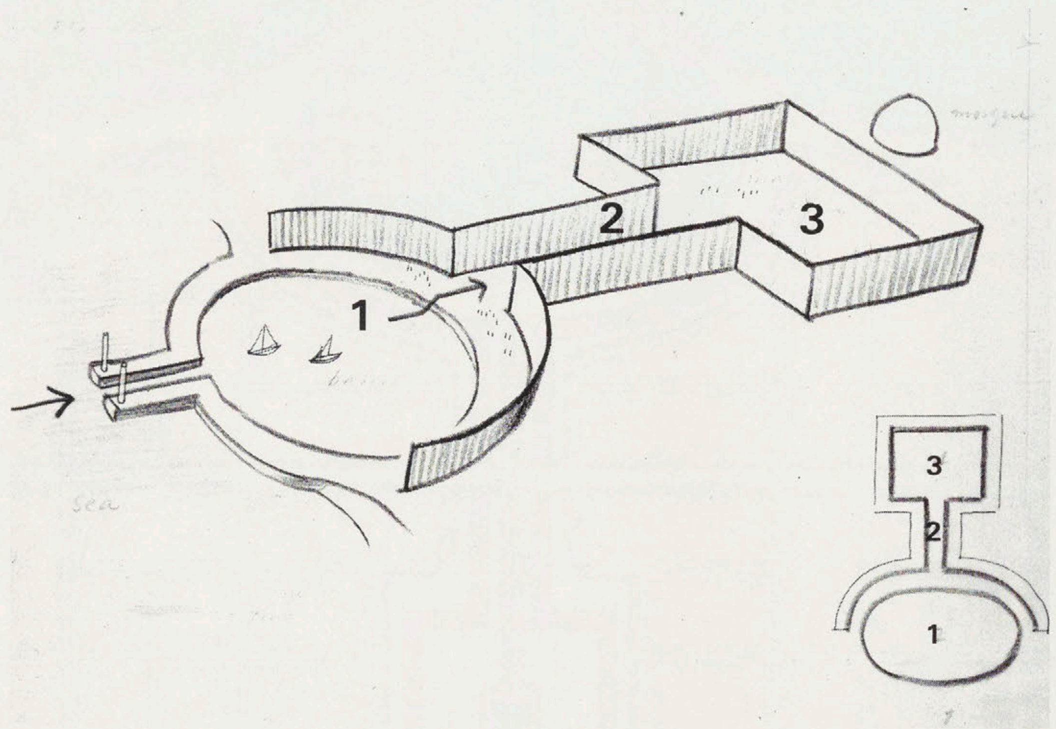
The central core

Many famous towns and cities have memorable spaces such as Trafalgar Square in London, Place de la Concorde in Paris and the most famous of all, St. Mark's Square in Venice. This gives a town an identity, something to which one can easily associate. We have designed such a space for Jebel Ali – a Crescent overlooking a yacht harbour, linked by a Boulevard to a Square. The boulevard is crossed by a tree-lined avenue. The development of this central space must be carried out to a harmonious design. The illustrations show the main activities of the central space.

Crescent
The Crescent, containing flats and possibly an hotel with shops, restaurants, and marina facilities on the ground floor, overlooks and contains the marina. The marina, principally designed for pleasure craft, would also enable local dhows to bring supplies such as fresh vegetables directly into the heart of the central area. The marina would have a relatively shallow depth, and the excavation would be a quick and simple operation if the massive equipment used in the nearby harbour works were employed in its construction.

Boulevard
A mixture of flats and offices with prestige shops and showrooms on the ground floor. face onto a pedestrian boulevard. Servicing is provided by the road framework to either side of the central space.

Central square and Mosque
The main central space, with trees, ornamental lakes and fountains is the heart of the town. The surrounding buildings would contain a mixture of civic uses, offices and residential accommodation. The southern side of the main Square is reduced in height to allow a full visual awareness of the Central Mosque. From the square a narrow avenue links to the Mosque and into the covered shopping mall.



Concept
A Crescent (1), a Boulevard (2) and a square (3), form the central space of the new town.

Avenue
A tree lined avenue bisects the central boulevard, providing an important east to west traffic link. The avenue forms an important feature of the Centre and care must be taken to ensure that it is lined by buildings of sufficiently high quality. Features punctuate the ends of the avenue, the pavilion in the centre of the town park being the most notable.

A model shows the architectural composition of the central core. To either side of this control space we have suggested how the Centre might develop as a series of individual buildings constructed within the framework of the overall road network, towards the edge of the model the buildings have been simplified into an overall massing study representing the building blocks.

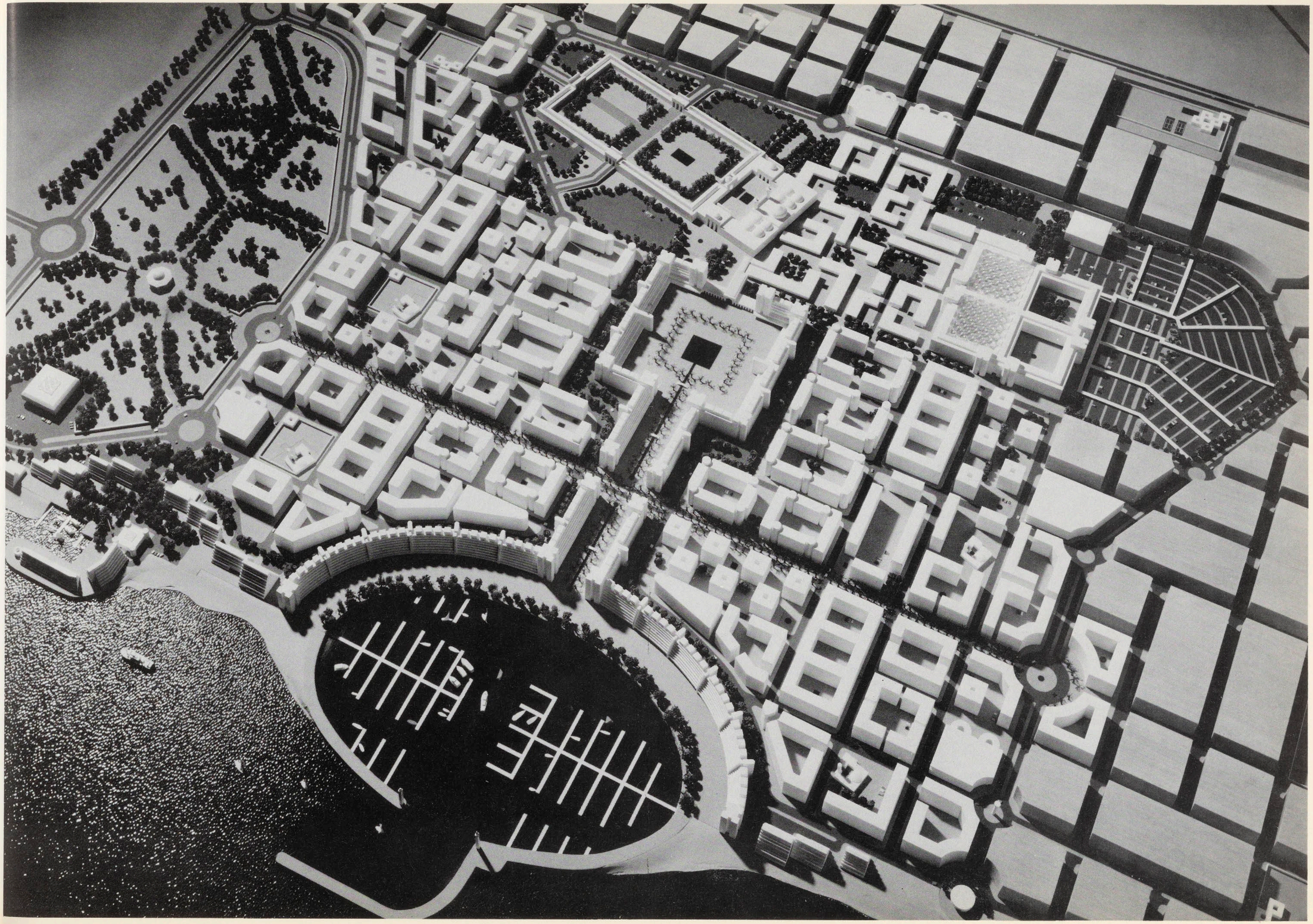


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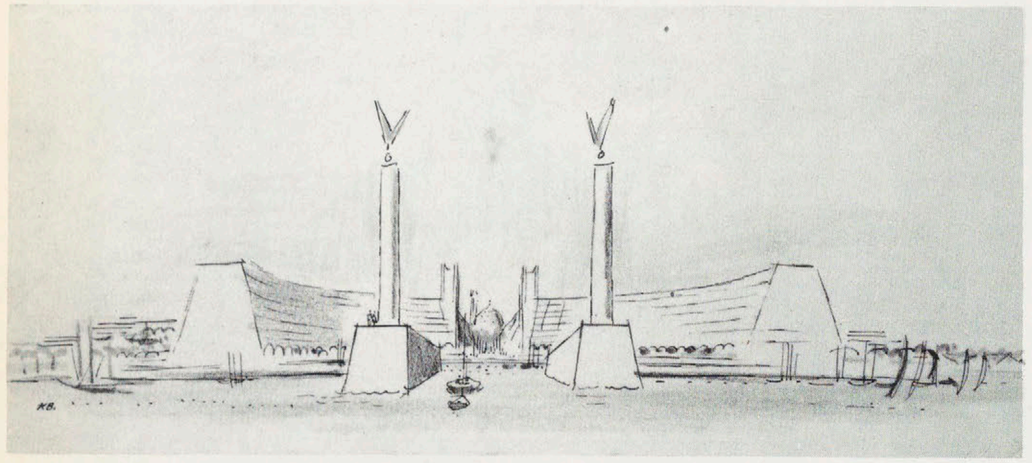
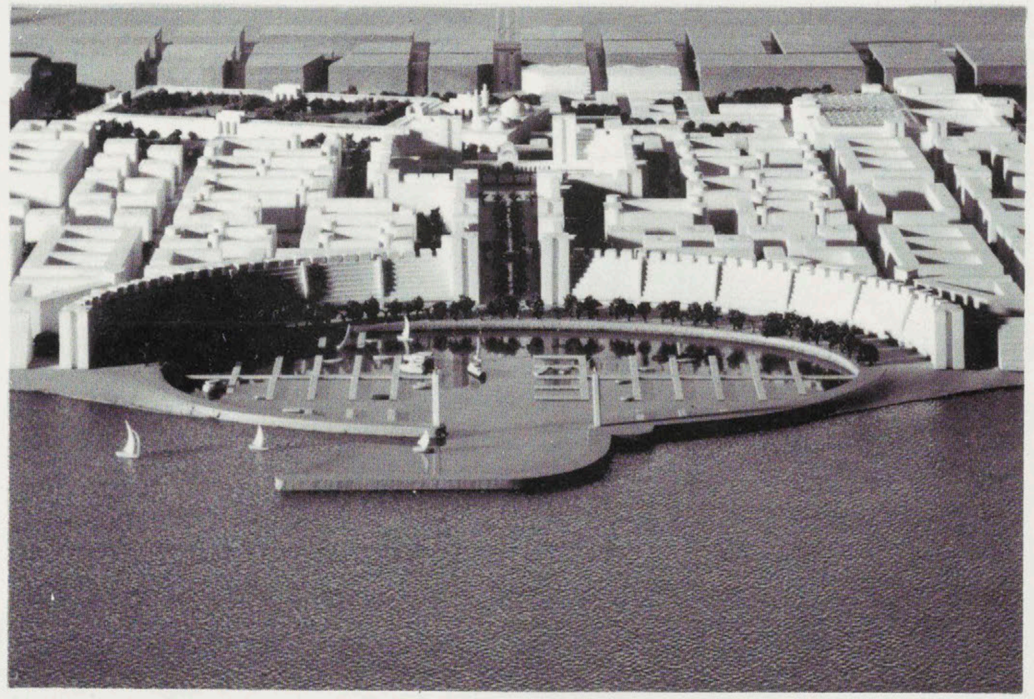
image from the sea —





The curve of the Crescent forms a welcome to those who approach the centre from the sea. Curved towers on each of the main approach roads mark the centre from the land.

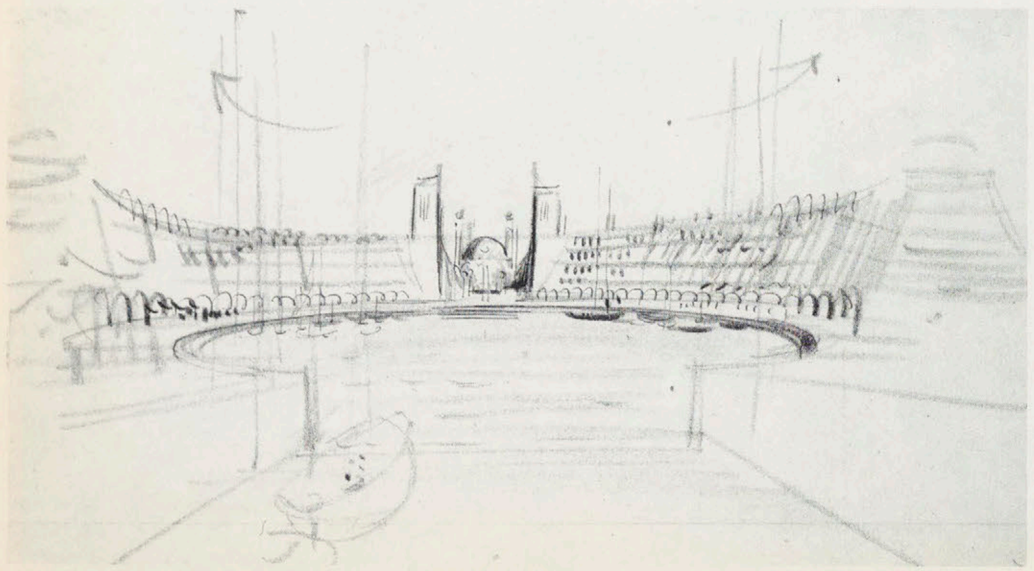


Image from the sea

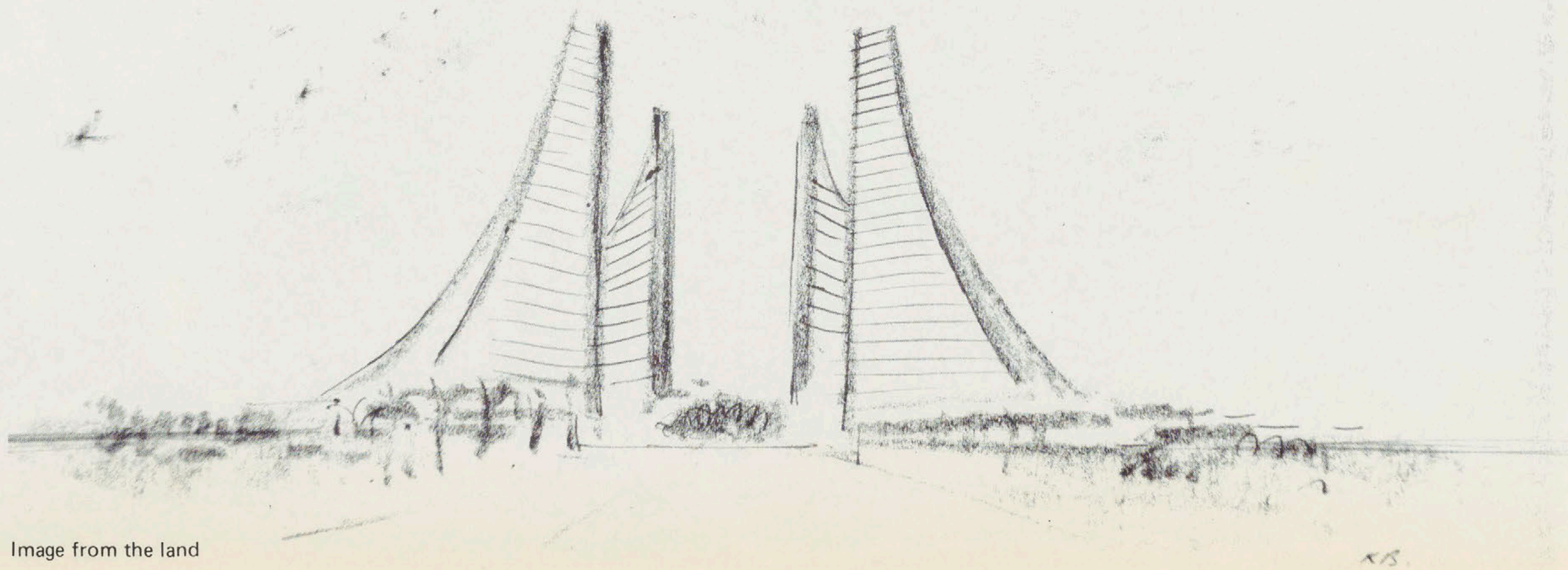
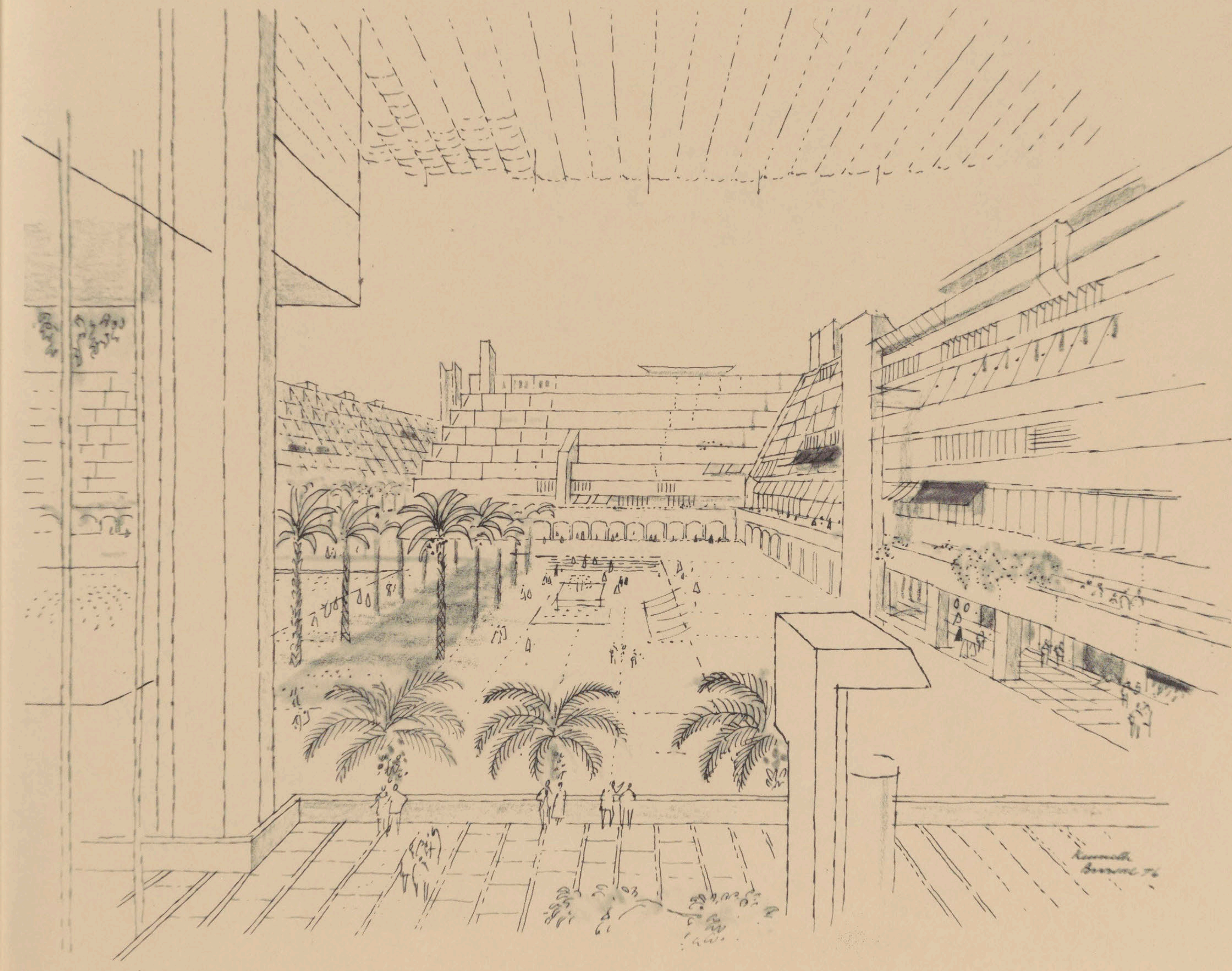
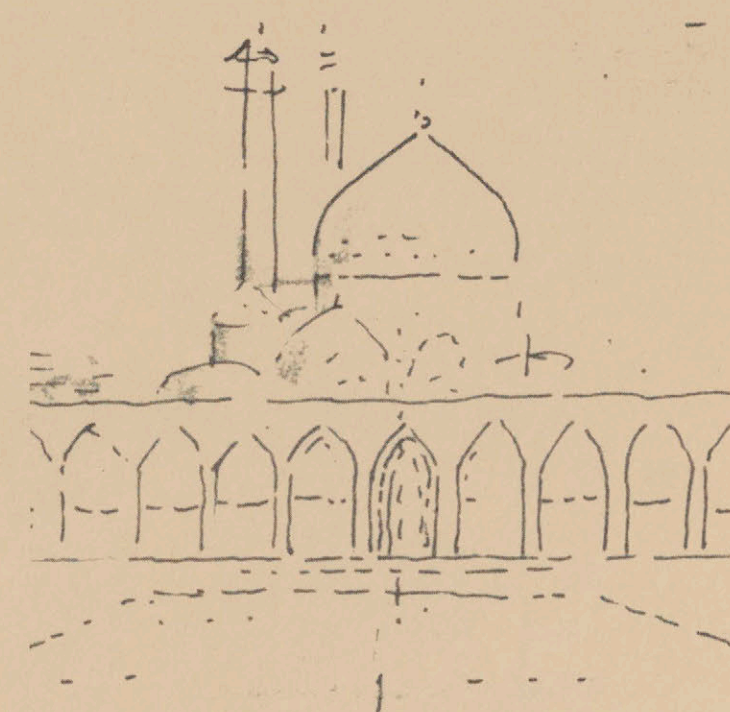


Image from the land





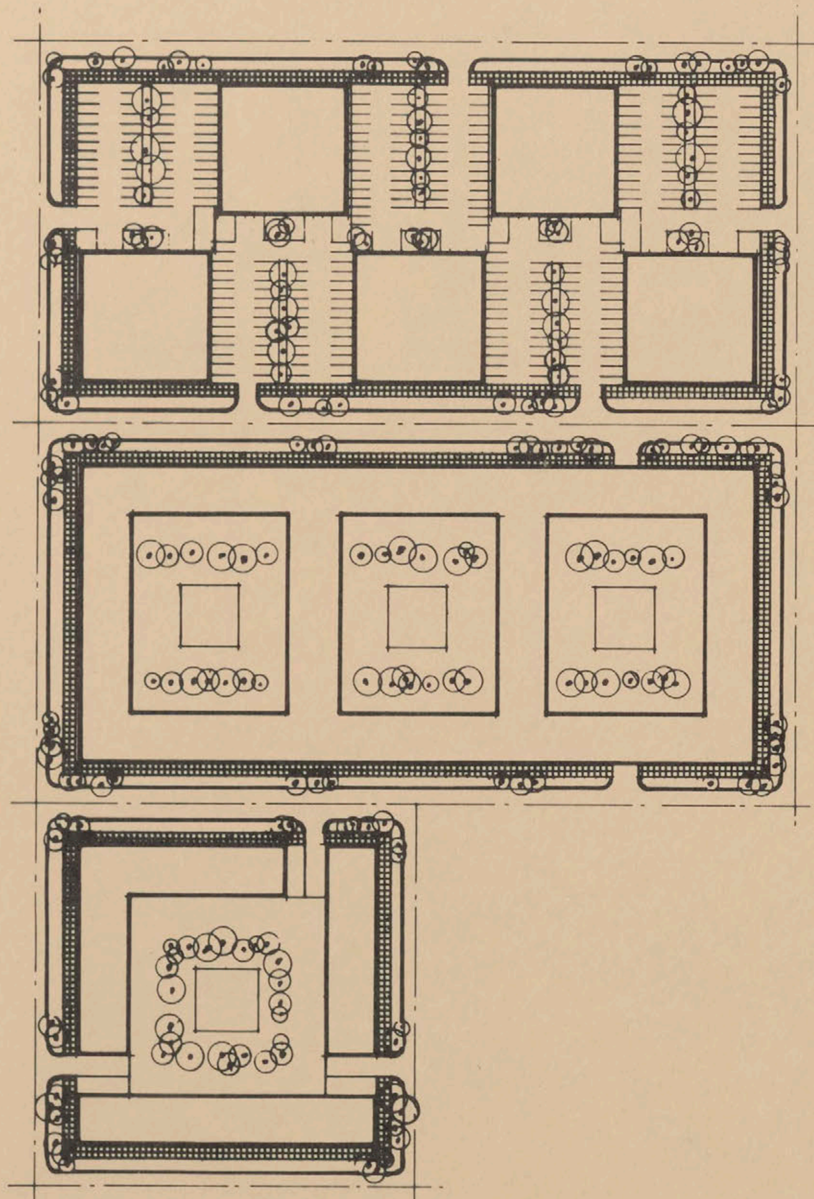
Screen wall allows a full visual awareness of the central mosque

Rashid square   Civic buildings

The outer core

The harmonious design of the central spaces will contrast with, but bring unity to, the surrounding development. The design of the buildings to either side of the core will be undertaken by many architects to the requirements of their clients. An overall guide to the form of the development will be derived from the road framework, density and planning requirements and building controls. But these necessary regulations should not suppress individual self expression. The main design requirements should be that of good taste and manners, each building respecting its neighbour and contributing towards the formation of good street architecture.

The street pattern is based upon a two hundred metre by one hundred metre grid, feeding off the main distributor roads on either side of the centre. Each grid is capable of being sub-divided into convenient building plots, and the diagrammatic plans illustrate some possibilities.

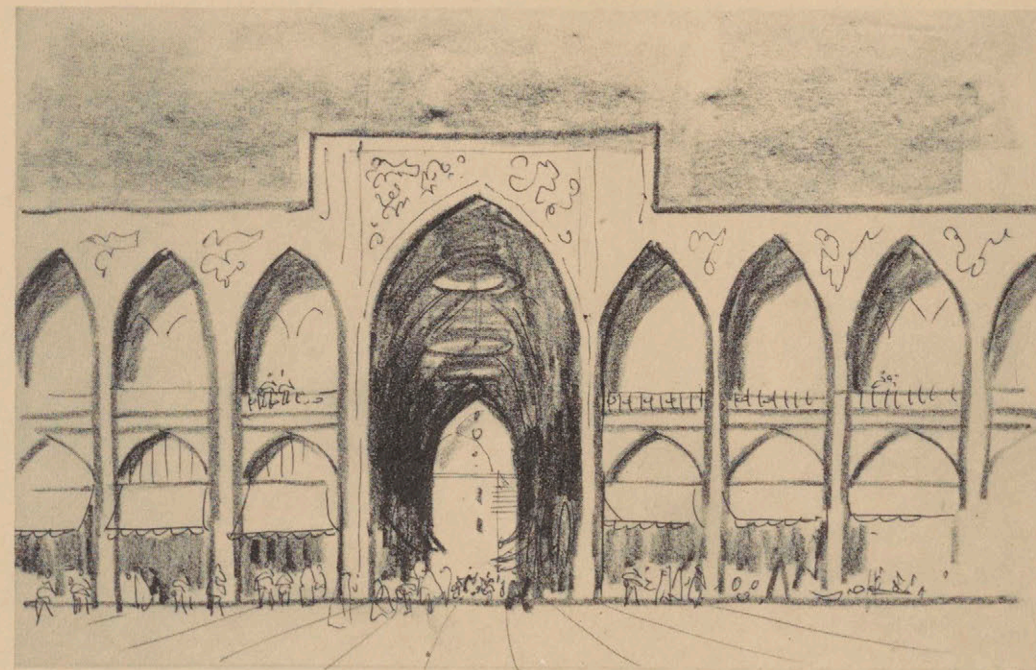


Plot ratio 3·5 to 1
Blocks 8 floors
1 floor commercial
42 flats
56 cars

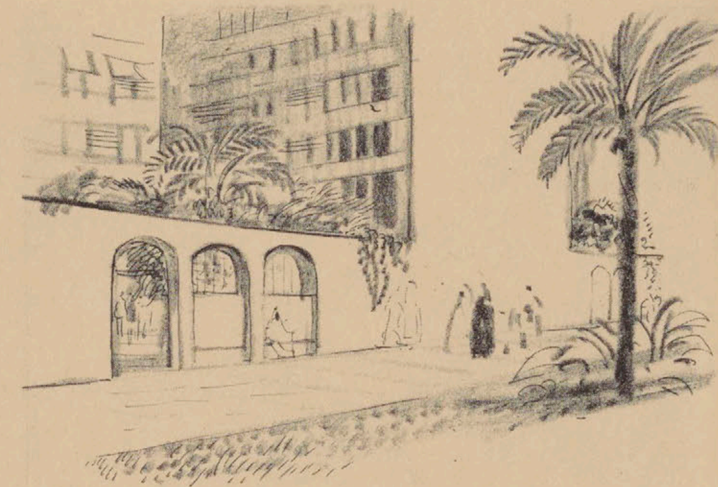
Alternative
Plot ratio 3·5 to 1
7 floors high
covered parking

Alternative
Plot ratio 3·5 to 1
8 floors high
covered parking

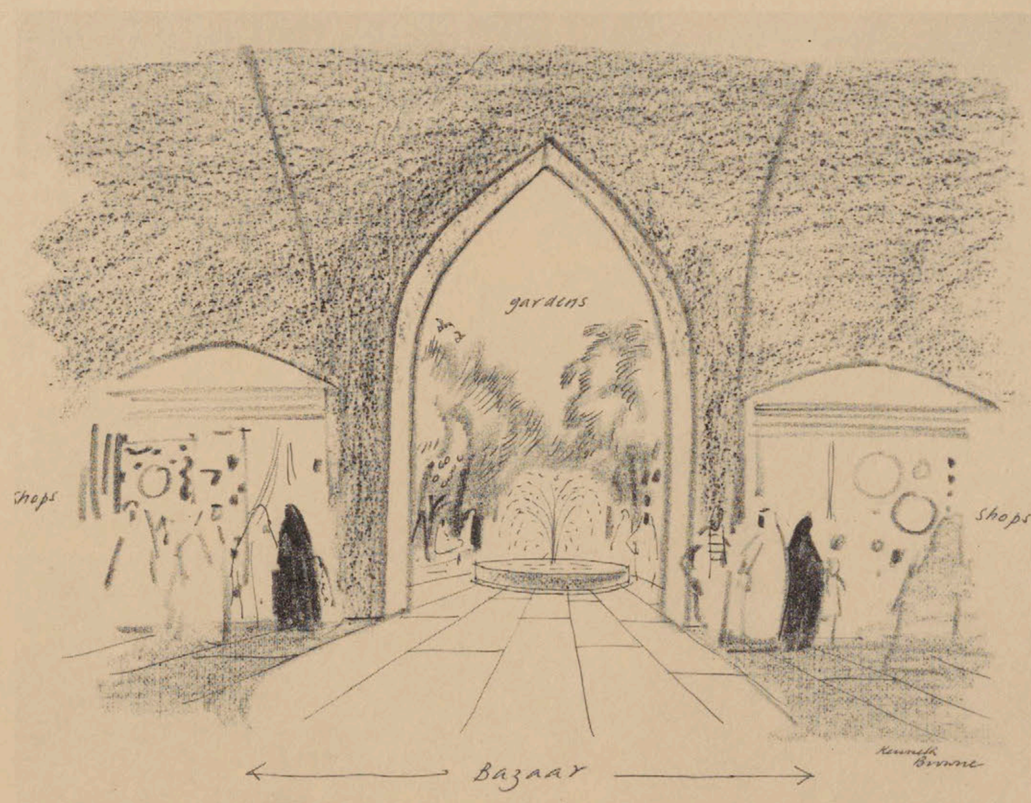
Diagrammatic layouts showing various ways of building within the 200 metre by 100 metre street grid.



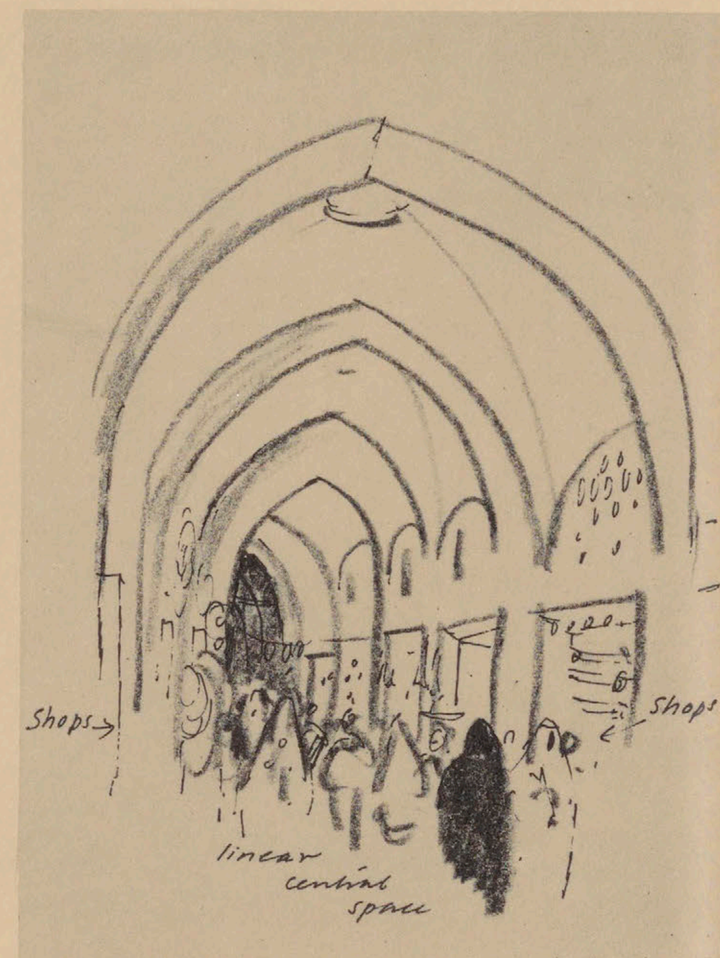
Screen wall of shops



Courtyard and gardens provide protection from street noise

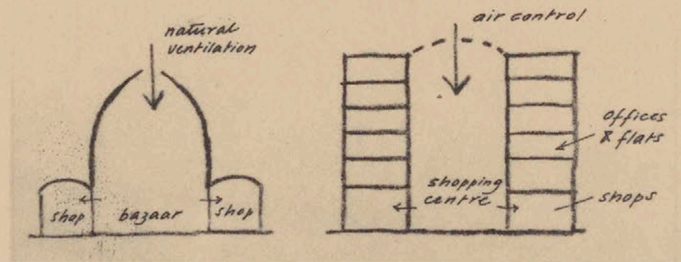


Approach to the shopping from the market

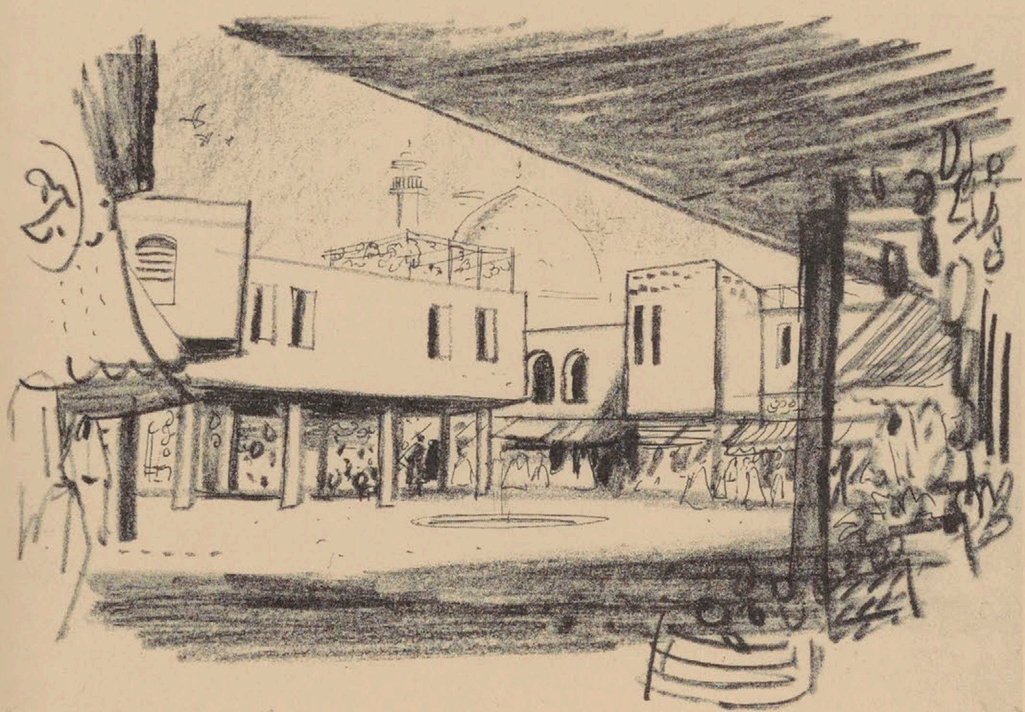


Shopping mall

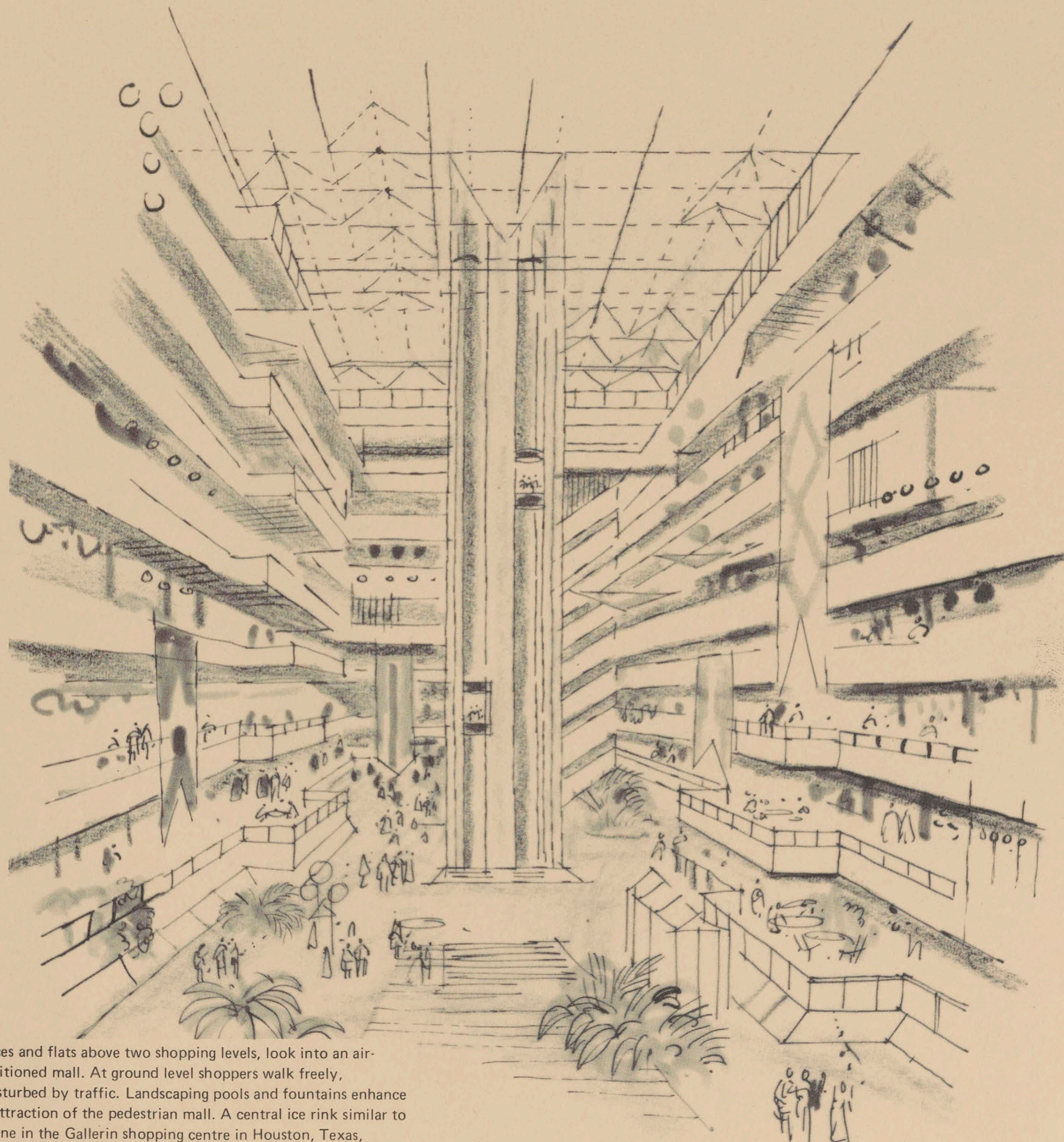
The Centre's major shopping area is conceived as a modern equivalent of the souk a large central space for shoppers lined with shops on each side. But the upper reaches of the mall become offices and air conditioning allows a glass roof to be provided, contrasting strongly with the darker cavern-like appearance of the souk. The shopping mall opens out onto two courtyards, an extensive car parking area on one side, and a bus/taxi station on the other. Between the mall and the Mosque is a low scale residential district, where smaller local shops and open air market could thrive.



The shopping mall is conceived as a modern equivalent of the souk.



Small scale residential district, with small shops and open air evening markets.



Offices and flats above two shopping levels, look into an air-conditioned mall. At ground level shoppers walk freely, undisturbed by traffic. Landscaping pools and fountains enhance the attraction of the pedestrian mall. A central ice rink similar to the one in the Gallerin shopping centre in Houston, Texas, where the climate is comparable to Dubai, would bring added interest and excitement to the area.

The avenue, looking towards the town park

Town park
The park screens the Town Centre from the industrial zone and provides an important breathing space for the city. An indoor recreation centre contains swimming pools, restaurants, squash courts and play areas. To the south of the park a sports and football stadium is located near the town's urban motorway system.

Land use
Space for social, recreational and educational needs has been provided within the Centre and these should be safeguarded until the demand warrants their construction. A mixed use policy is advocated for most parts of the Centre, allowing the buildings to be used for commercial or residential use. The Centre must be capable of adjusting to the changing demands brought about by the expanding town and flexibility of use within buildings will enable it to meet this challenge. The demand initially will be for flats, which in turn will give way to pressure for increasing office accommodation as the town and industry develop. Shopping needs can be more easily met by the extension of the main shopping complex, but the ground floor of many buildings could be converted for shop or showroom use as the demand arises.

Figure 24 indicates broad zones within which selected activities should be encouraged to concentrate. These guide lines will bring greater convenience to people using the area, shops for example will be grouped together; furthermore it will help the Centre to develop as a variety of areas, each with its own character and identity.

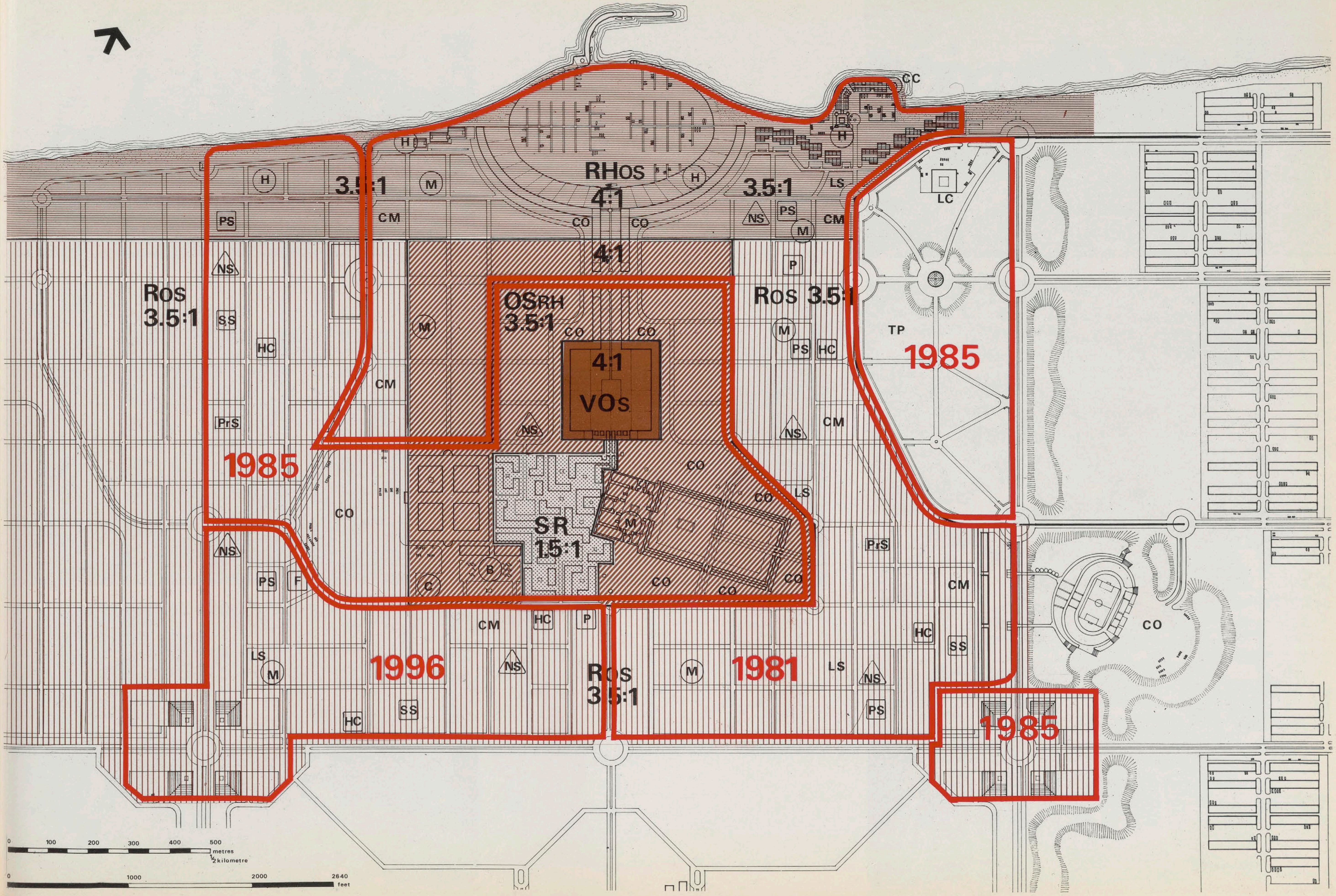
The massing of buildings is important not only in design terms but in order to balance the various activities with the transport network that serves them. We therefore propose a system of plot ratios (ratio of total floor space to site area) to control the quantity of accommodation on any one site. The majority of the Centre has been allocated a plot ratio of 3.5:1 rising to 4:1 for the central core. A plot ratio of 1.5:1 is recommended for the small scale residential and shopping area between the Central Mosque and the main shopping centre. These plot ratio guide lines are useful tools but a final decision on the exact ratio will need to be based on more detailed design studies. This is discussed further in Chapter 11.

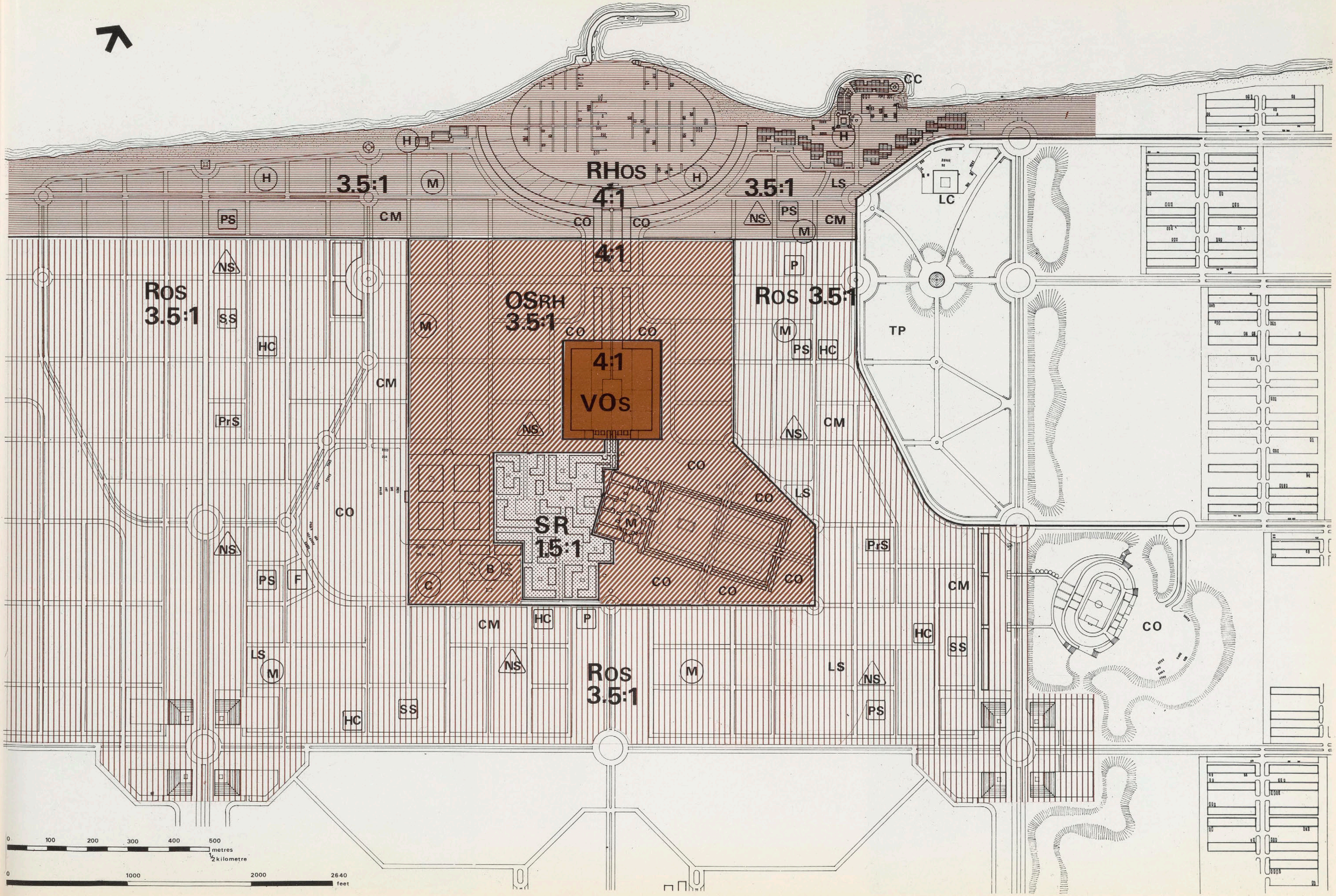
Phasing
The Town Centre phasing plans show how it could develop, starting with the Crescent and marina and gradually extending inland.

Car parking
Parking for visitors could take place on some streets, but each building must provide adequate off street parking for use by its occupiers. The schematic building design shows how the cars could be grouped in the central courtyard or placed in a semi-basement. If for certain reasons the developer does not wish to provide parking within the building curtilage, a levy could be introduced for each space not provided, and the proceeds would contribute towards the construction of public multi storey car parks.

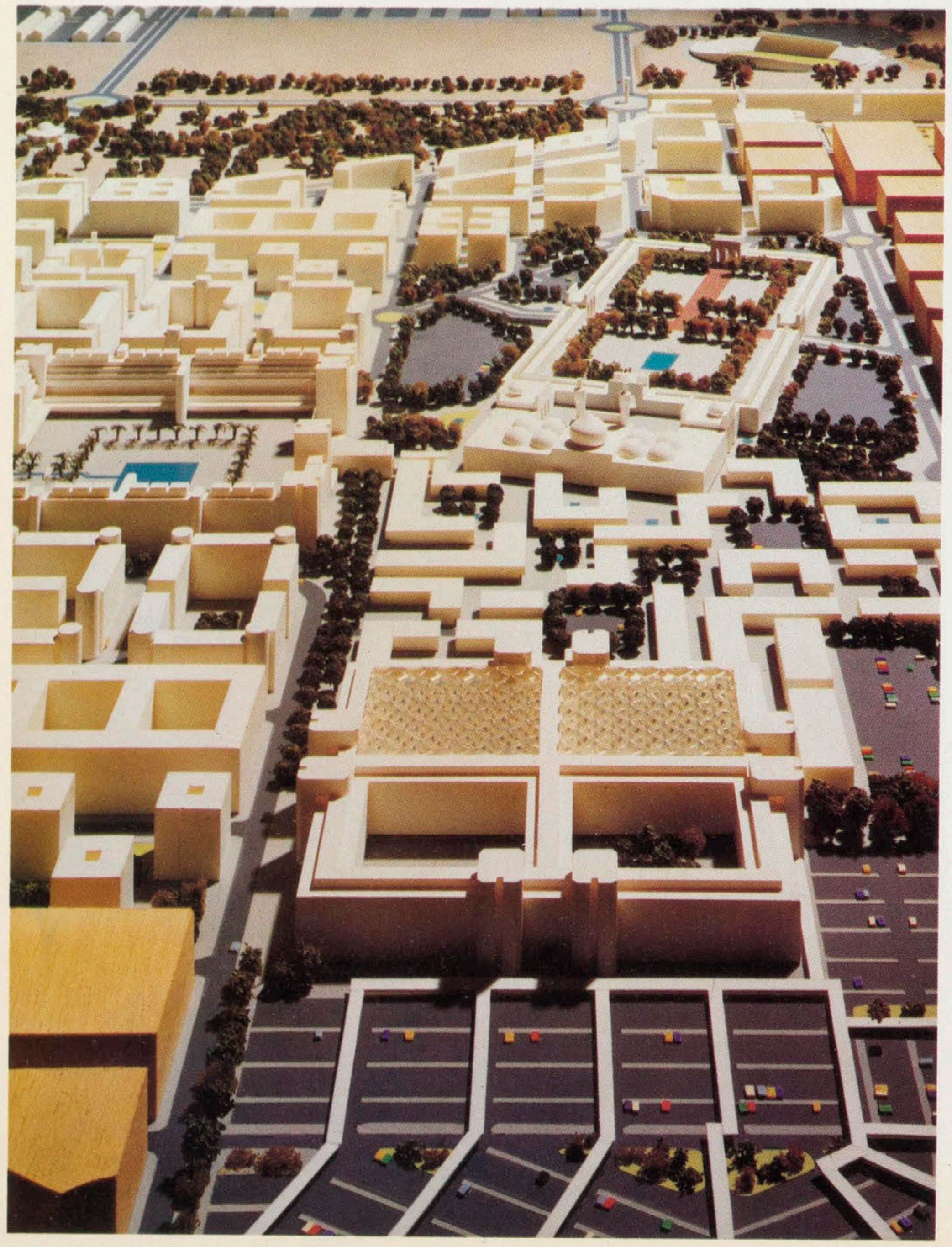
24 Land use and phasing

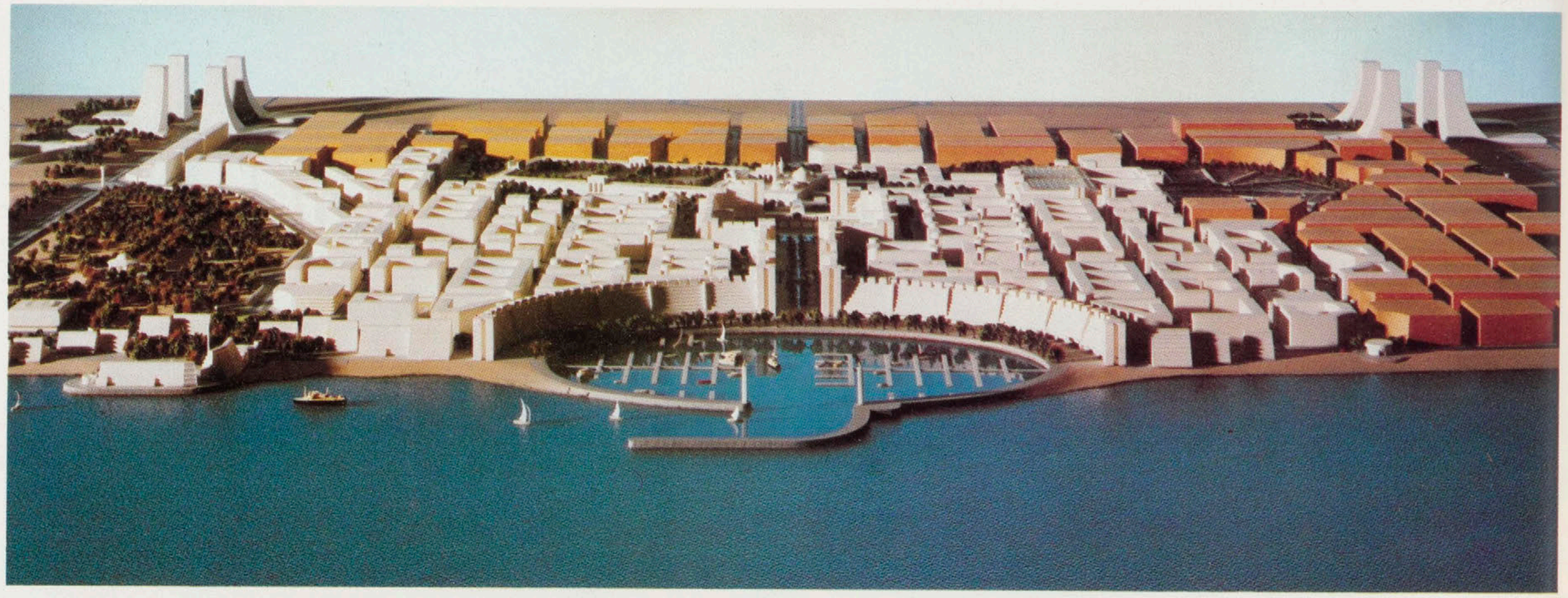
M	Mosque
HC	health clinic
NS	nursery school
PS	primary school
PrS	preparatory school
SS	secondary school
F	fire station
P	police station
B	bus and taxi station
CO	open car parking
CM	multi storey car park
TP	town park
LS	indoor leisure centre
CC	country club
C	cinema
H	hotel
V	civic building
O	office
S	shopping with
R	residential
S	primary use
S	secondary use
3.5 : 1	plot ratio

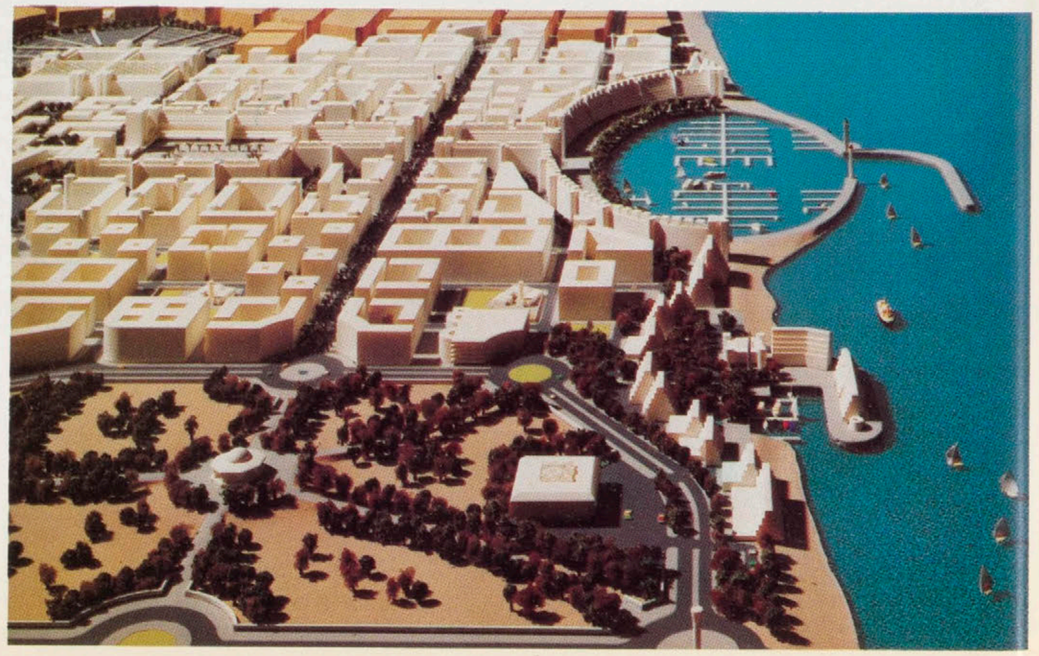

RHOS
4:1
3.5:1
3.5:1
CC
LC
CM
CO
CO
4:1
ROS
3.5:1
OSRH
3.5:1
ROS 3.5:1
TP
1985
4:1
VOS
1985
SR
1.5:1
CO
PrS
CM
1996
ROS
3.5:1
1981
1985
CO
metres
½ kilometre
feet


RHOS
4:1
3.5:1
3.5:1
CC
H
M
LS
LC
PS
CM
CO
CO
NS
4:1
Ros
3.5:1
OSRH
3.5:1
Ros 3.5:1
TP
SS
HC
M
PS
HC
4:1
VOs
CM
PrS
NS
NS
CM
CO
CO
LS
S R
1.5:1
CO
M
PrS
NS
PS
F
B
C
CO
CO
CO
CM
CM
HC
P
HC
SS
CO
LS
M
NS
Ros
3.5:1
M
LS
NS
HC
SS
PS
0
100
200
300
400
500
metres
½ kilometre
0
1000
2000
2640
feet

A central core in the form of a Crescent, a Boulevard and Square provides the nucleus for the town's development. The development of this central space must be undertaken to a harmonious design contrasting with, but bringing unity to, the surrounding development.

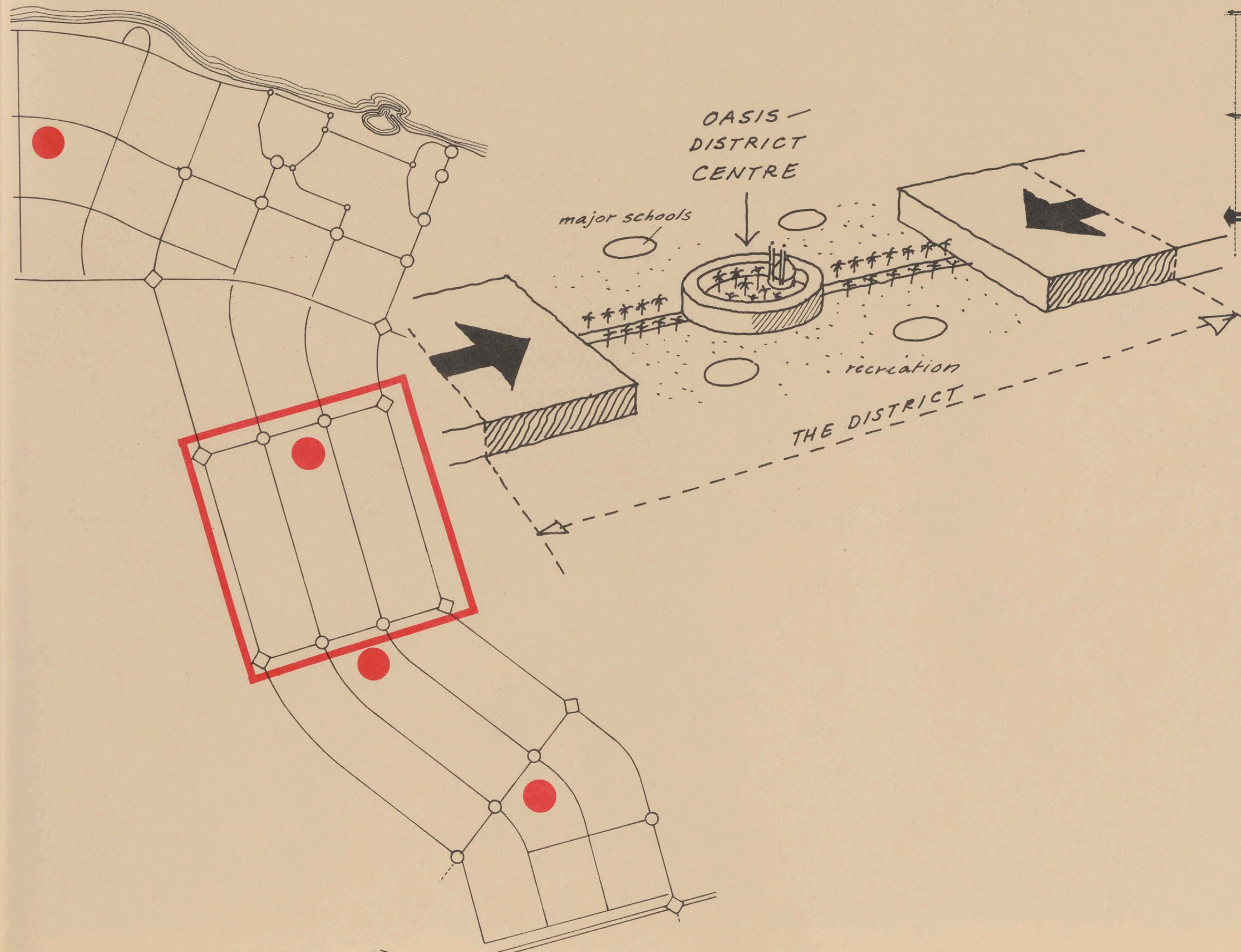






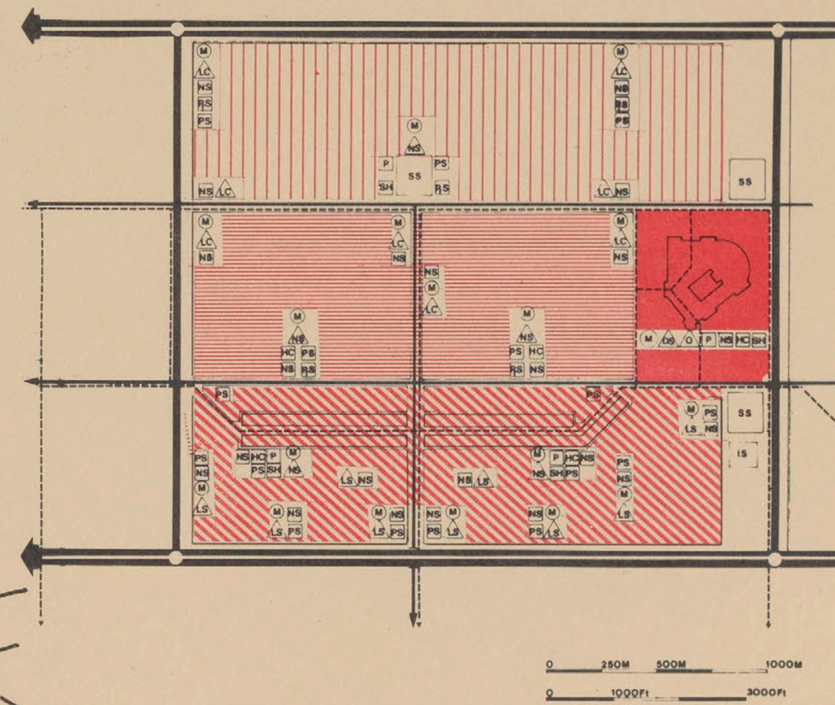
Chapter 9
The district

The District houses some 73,000 people and is composed of three main elements, the District Centre; Local Centre; the medium to high residential neighbourhood and the low-income neighbourhood. The final district to be constructed in 1997 – 2007 could have a different character than the others, being largely for low-income residents and with an overall population of 102,000. This larger district could be conceived as an almost separate town with its own identity and form; such an idea which gives rise to numerous exciting possibilities will need to be fully explored at a later and more appropriate point in time.



25
The district

The linear development of the town comprises four districts with their own centres and identity.



NS	Neighbourhood Centre
LS/C	Local Centre
M	Mosque
HC	Health Clinic
NS	Nursery School
PS	Primary School
PrS	Preparatory School
SS	Secondary School
IS	Islamic School
F	Fire station
PL	Police station
B	Bus and taxi station
C	Cinema
SH	Sports hall

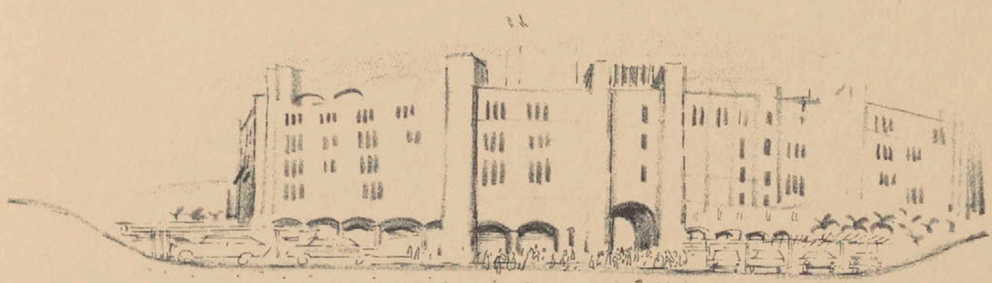
District Centre

Low income housing

Middle income housing

high income housing

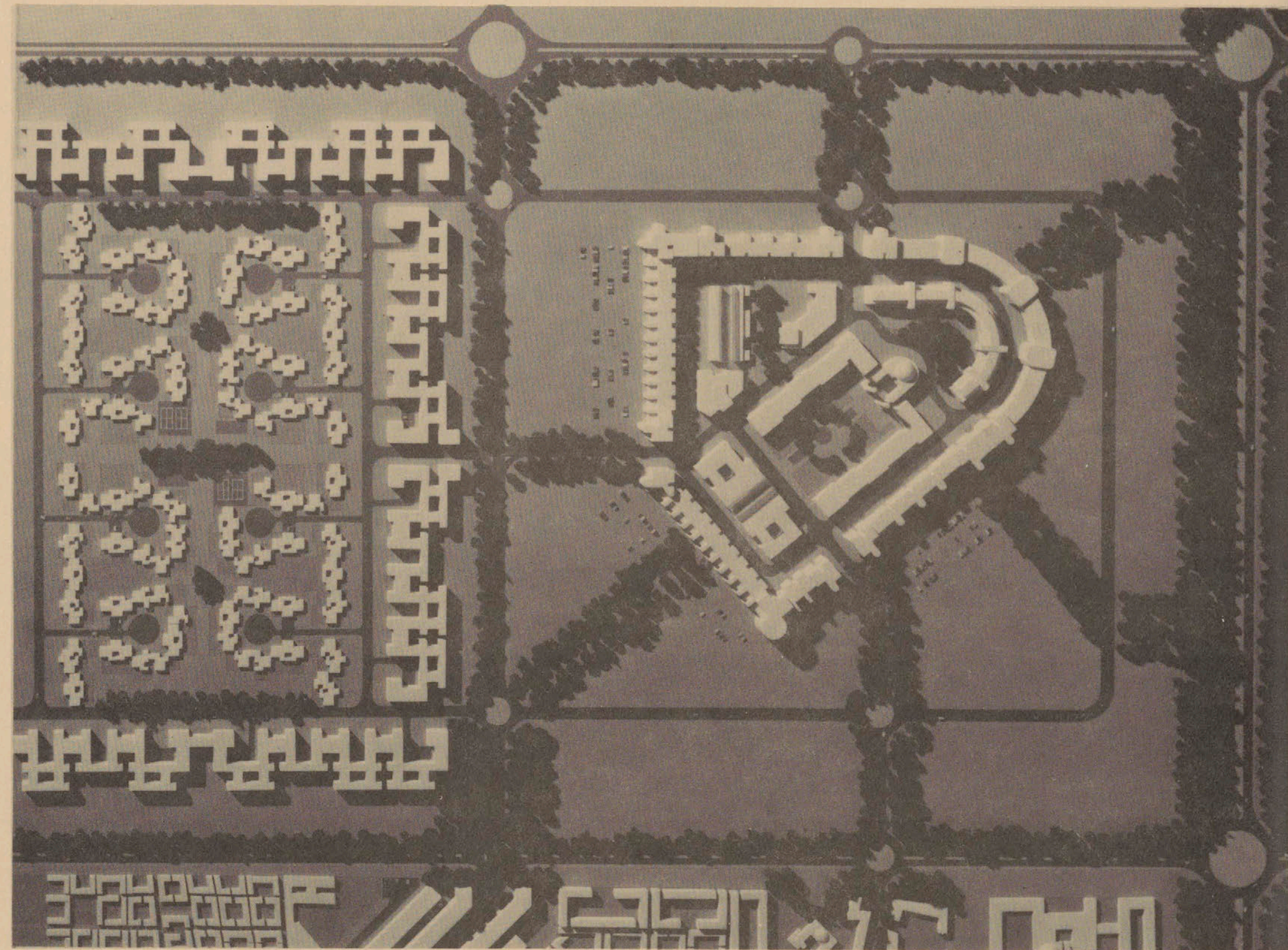
The district centre

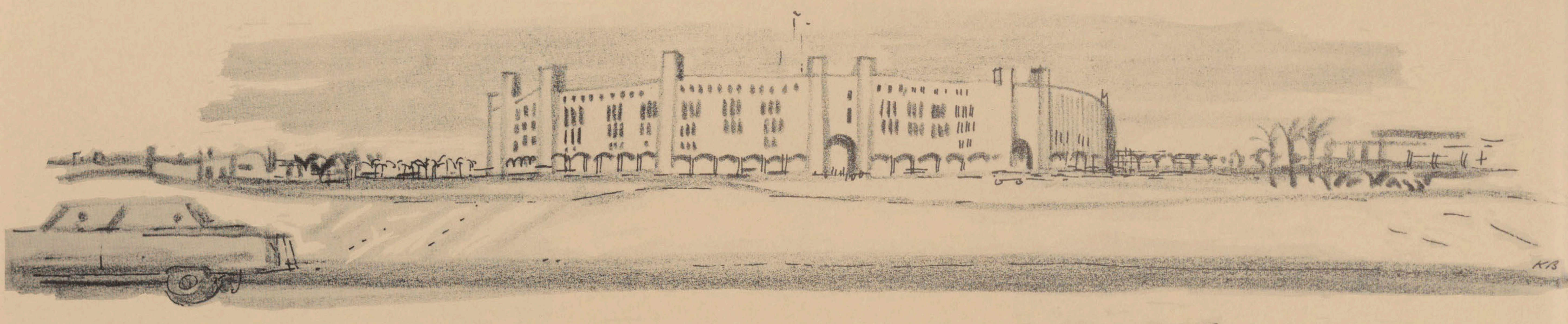


district centre

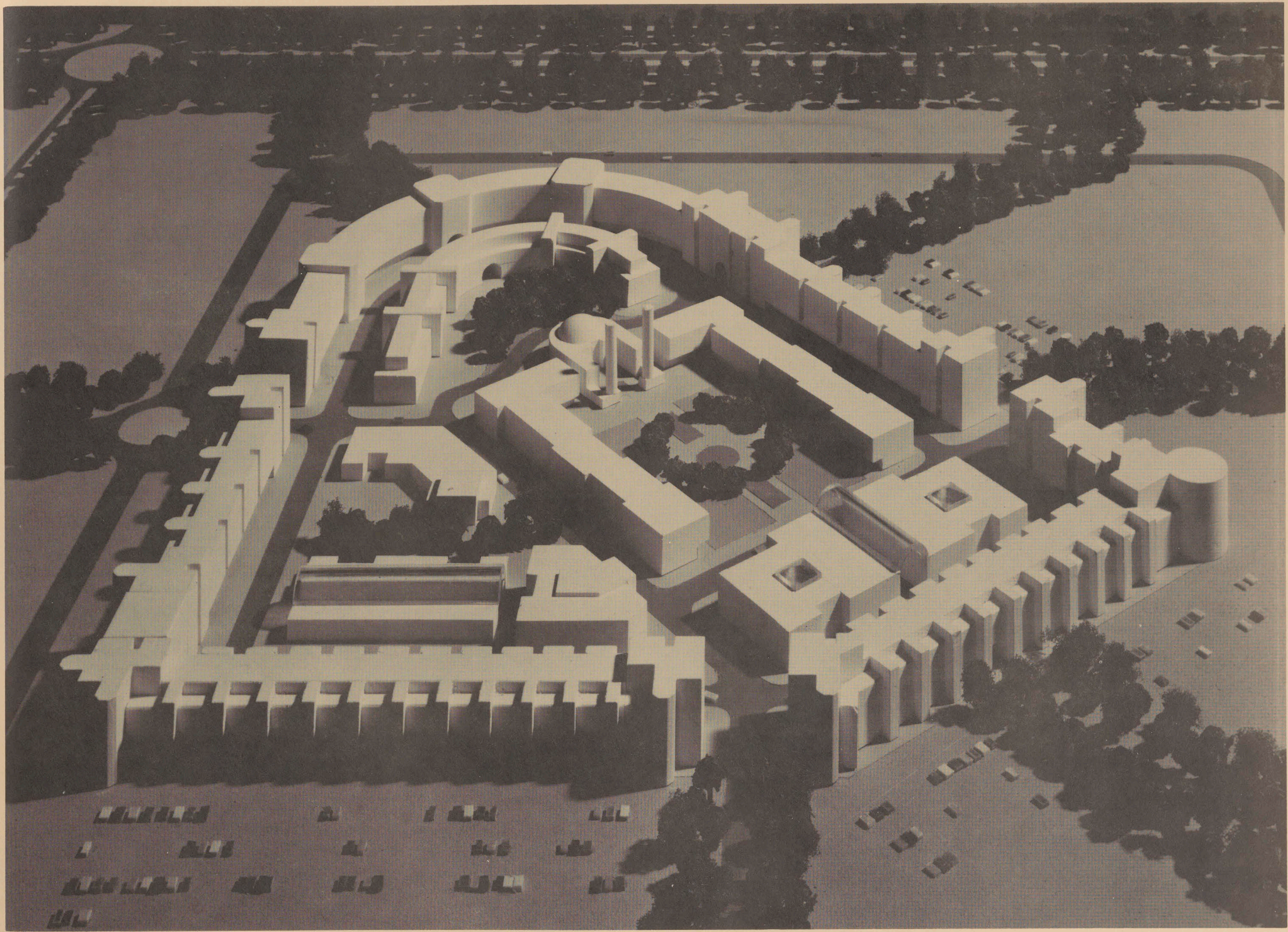
Four District Centres are provided for in the Master Plan, to provide greater convenience for people living in the districts; to remove undue pressure and congestion from the town centre; to allow journeys throughout the town to be more evenly distributed and thereby allowing a more economic transport system to evolve.

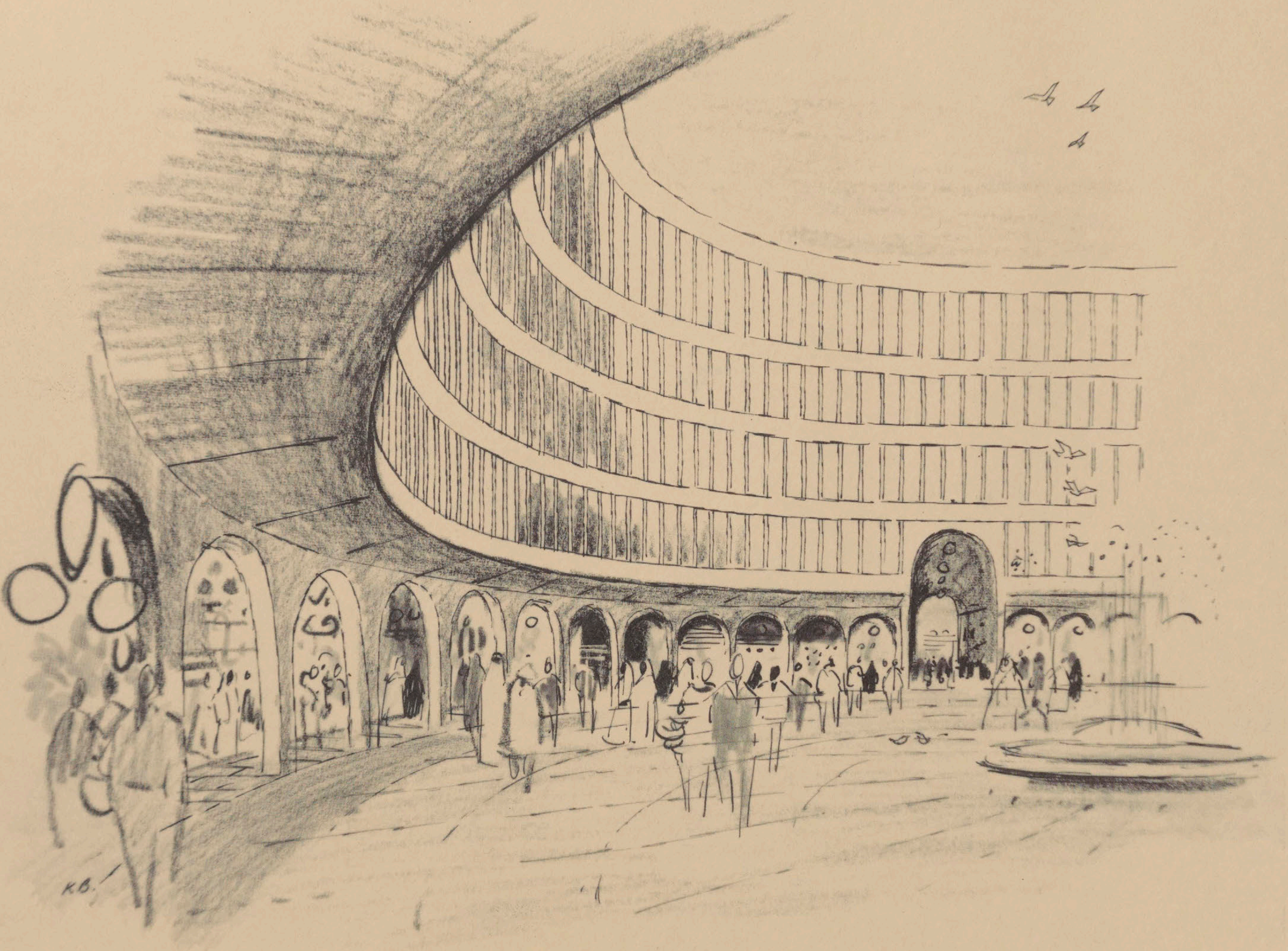
Each centre provides for the many needs of some 73,000 people in the surrounding district and is in effect a town in miniature, a lively, colourful, bustling place of markets, shops, flats, offices etc. The last centre to be built in phase four will serve a district of some 102,000 low-income residents.





district centre





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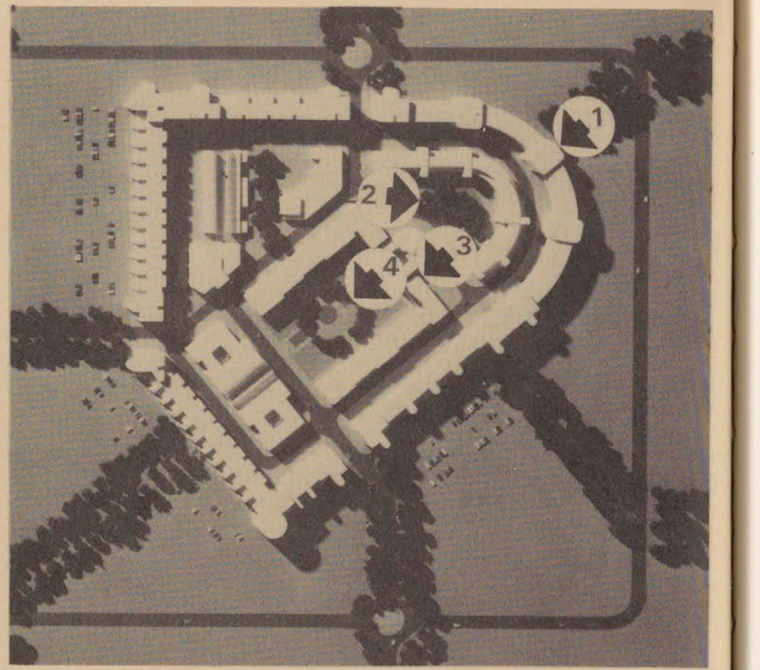
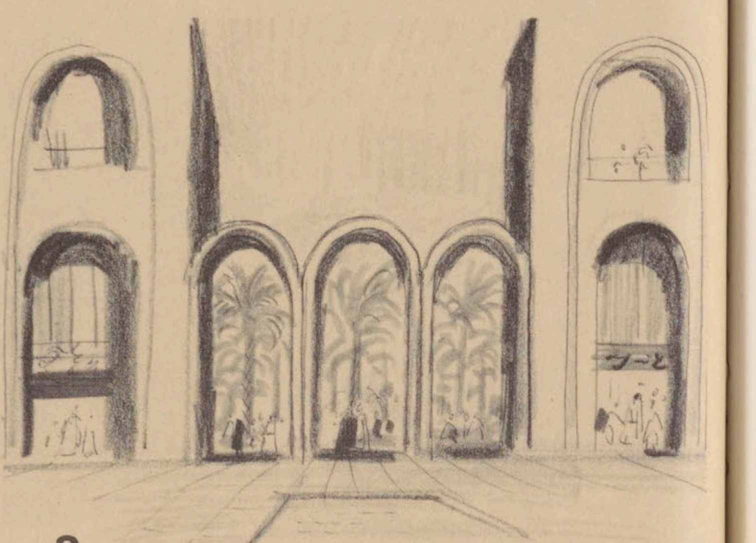


1



3


Kenneth Browne

The low-income neighbourhood

Most semi and unskilled workers and their families will be housed alongside the light industrial zone. As industry expands so will the housing supply need to keep pace. The width of the strip of open land separating the residential and industrial zones and the size of the industrial area will require most journeys to work to be taken by car/taxi or public transport.

Within the Neighbourhood a range of services, including shops, schools, health centres and open space will need to be provided. The principal component of the neighbourhood is the dwelling group which should be designed to an integrated form, and access and amenity needs such as shops and primary schools, should be provided within easy walking distance.

We have prepared a layout plan for a Neighbourhood of some 18,000 people in order to visualise how these various space requirements for roads, houses, shops, schools, etc. could be arranged to create an attractive environment, figure 26. Whilst there are many ways in which the Neighbourhood could be laid out, there is one fundamental principle and that is the need to break away from the rigid grid pattern imposed by the major road system.

The layout is orientated along a series of major pedestrian routes leading towards the Neighbourhood high street. The Local Centres create incidents along the route and a major square is formed at the Neighbourhood Centre. These and smaller spaces allow adults and families to meet and play within the tight environment of the close housing groups. In order to maintain this sense of privacy and enclosure, large open spaces including secondary schools are located outside the Neighbourhood and within the green separation strip of open land near the District Centre.

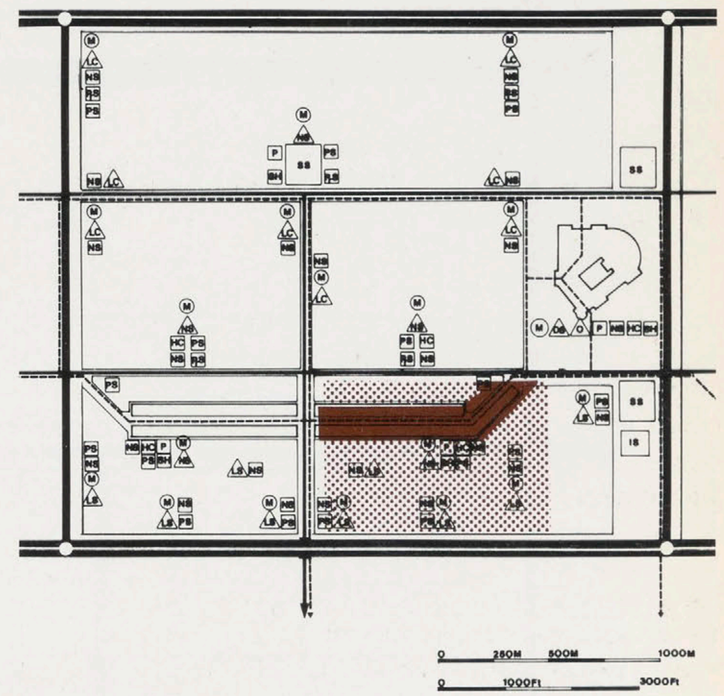
It is essential that land should be safeguarded even though the facility, say a primary school, is not built in the initial phase of the Neighbourhood's development. Provision of essential services should, however, not wait until the optimum population for supporting the facility is realised. Shops, a mosque, minimum health and education services should be given equal importance with roads and drainage and provided as part of the essential infrastructure of the area.

26
Low income neighbourhood

The diagrammatic layout shows how the various space requirements for roads, shops, schools, etc. could be arranged to create an attractive environment.

NS	Neighbourhood Centre
LS	Local Centre
M	Mosque
HC	health clinic
NS	nursery school
P	primary school
Pr	preparatory school
SS	secondary school
F	fire station
P	police station
B	bus and taxi station
CO	open car parking
C	cinema
MH	meeting hall

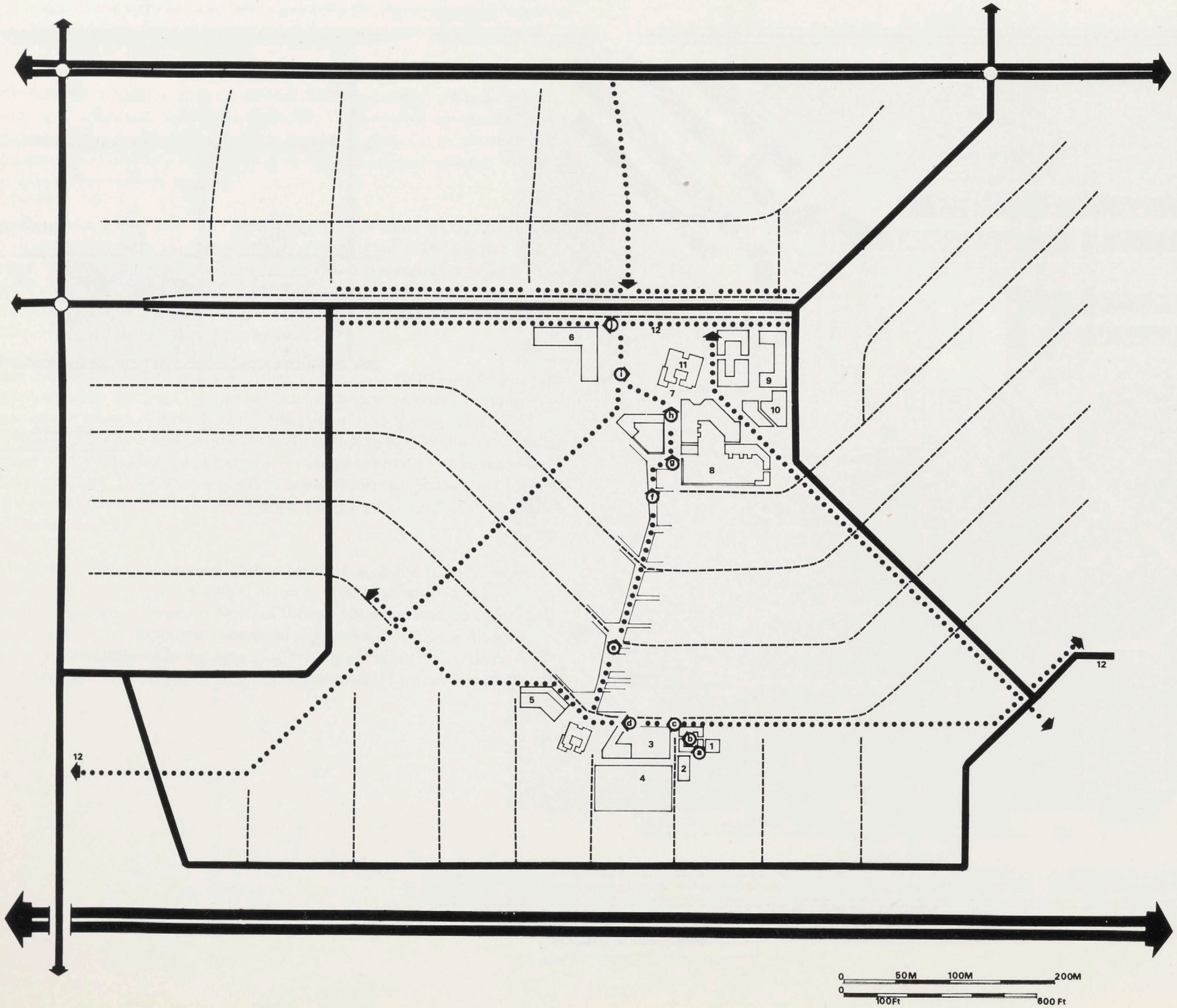
The low-income neighbourhood



houses

flats – neighbourhood high street

27 Neighbourhood road network



primary distributor

secondary distributor

district distributor

local road

main pedestrian route

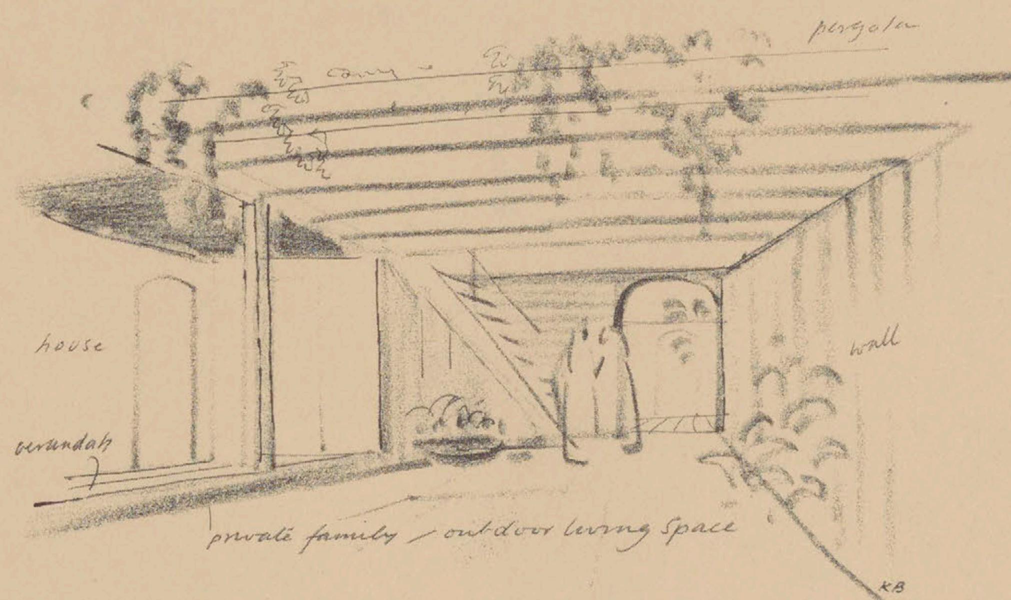
perspective view point

Major roads are located outside the Neighbourhood's boundary to carry all "through" traffic (i.e. traffic that has not come from the Neighbourhood itself). The internal street system serves only the Neighbourhood, and its design will be related to environmental needs rather than highway engineering standards, figure 27.

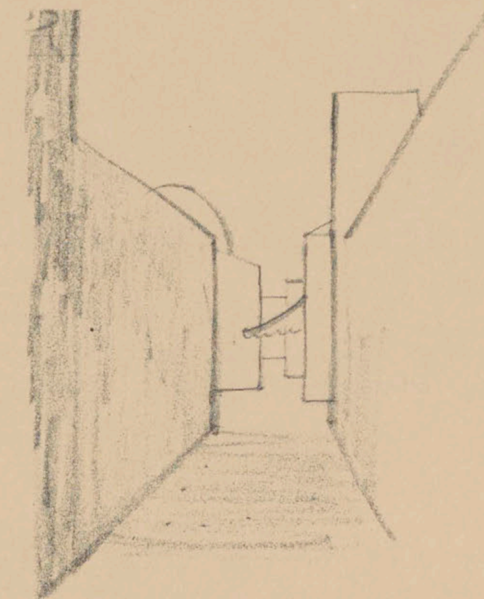
The perspective sketches take us on a walk through the Neighbourhood, starting at a typical house and moving along one of the major pedestrian routes, past the Local Centre to the Neighbourhood Centre and high street.

Summary of acceptable walking distances within a Low Income Neighbourhood

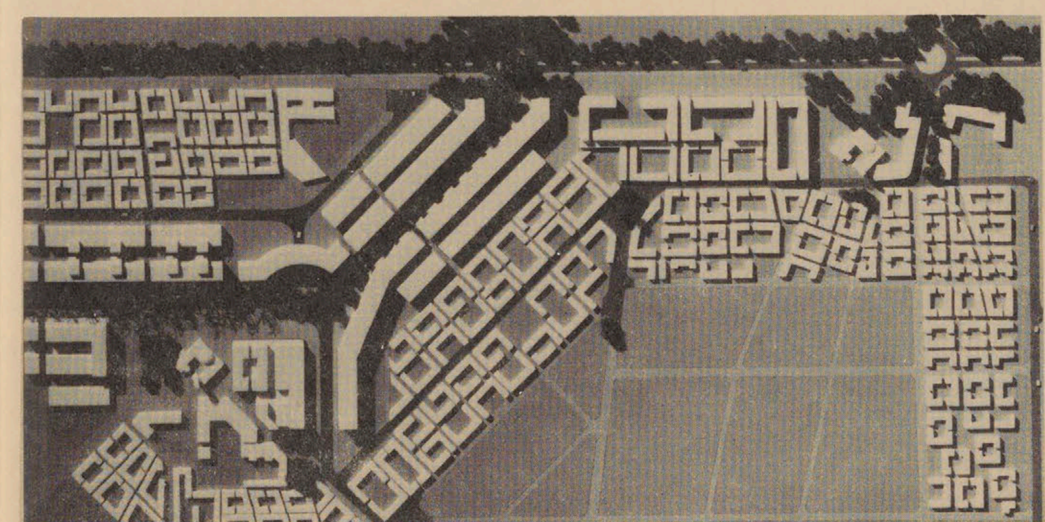
		Maximum walking distance
1.	Small childrens' play areas next to homes	50m
2.	Group car parking spaces	50m
3.	Nursery school	250m
4.	Amenity open space including childrens' play area	250m
5.	Local shops	250m
6.	Local workshops	500m
7.	Neighbourhood Centre	500m
8.	Primary school	500m
9.	Dispensary/health clinic	500m
10.	Post office/police station	500m
11.	Mosque	500m
12.	Bus stop	500m
	All other facilities such as the District Centre, secondary schools	Car/bus/taxi

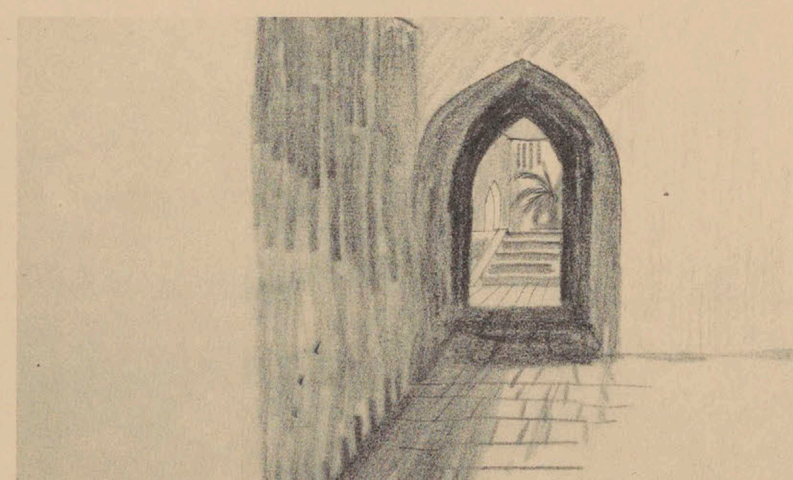


a The family court inside the house

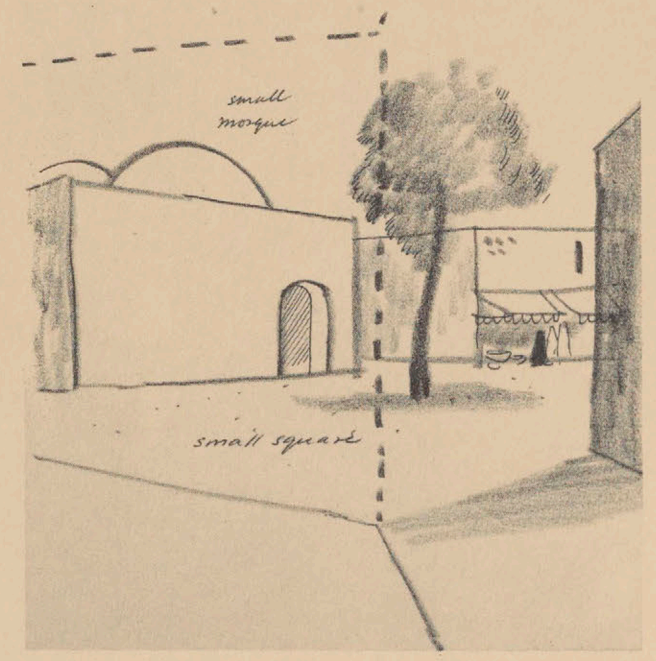


c At the end of the street the small square of the local centre is glimpsed

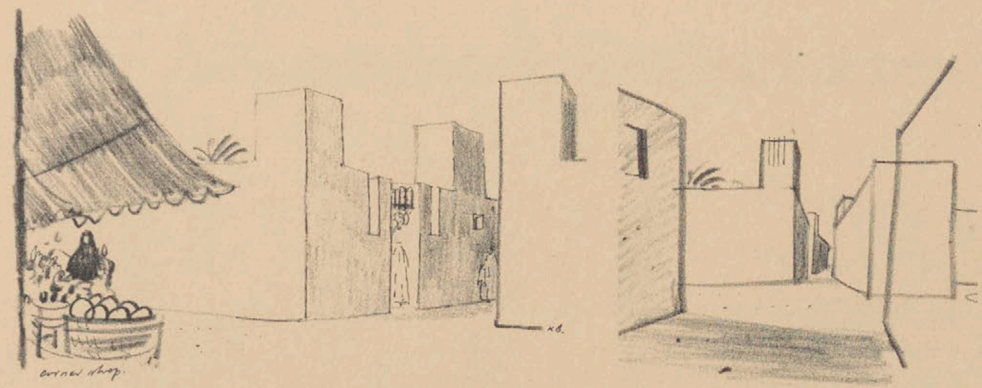




b Between the houses a passage leads to the street

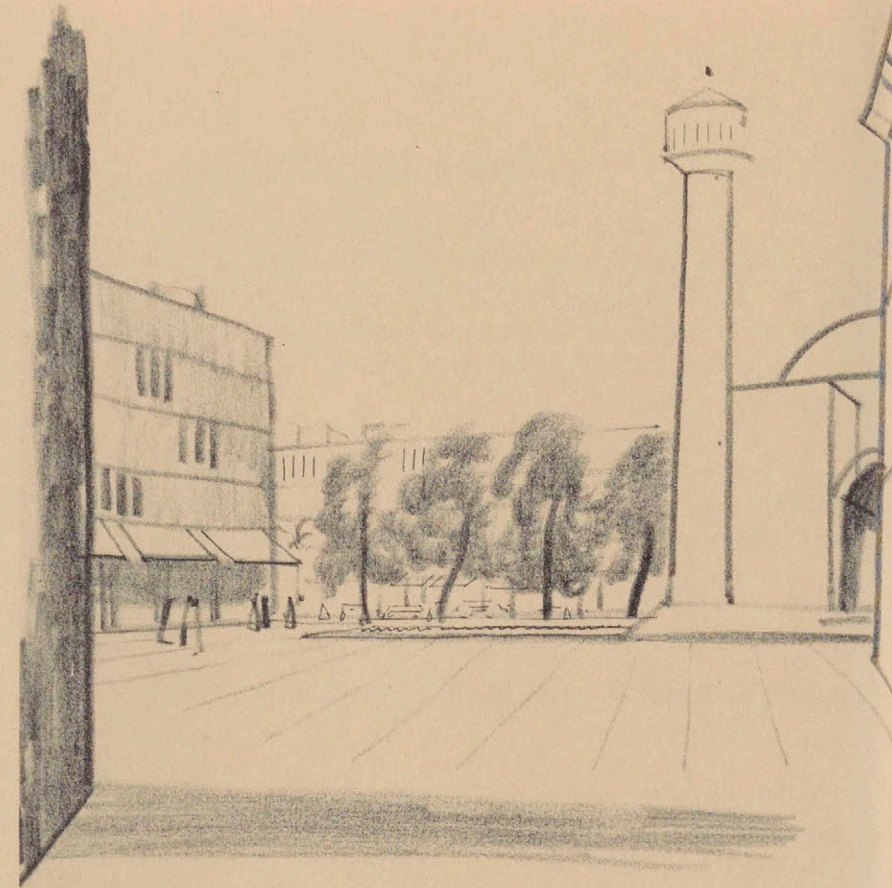


d The local centre comprising a mosque, shops and nursery and primary schools

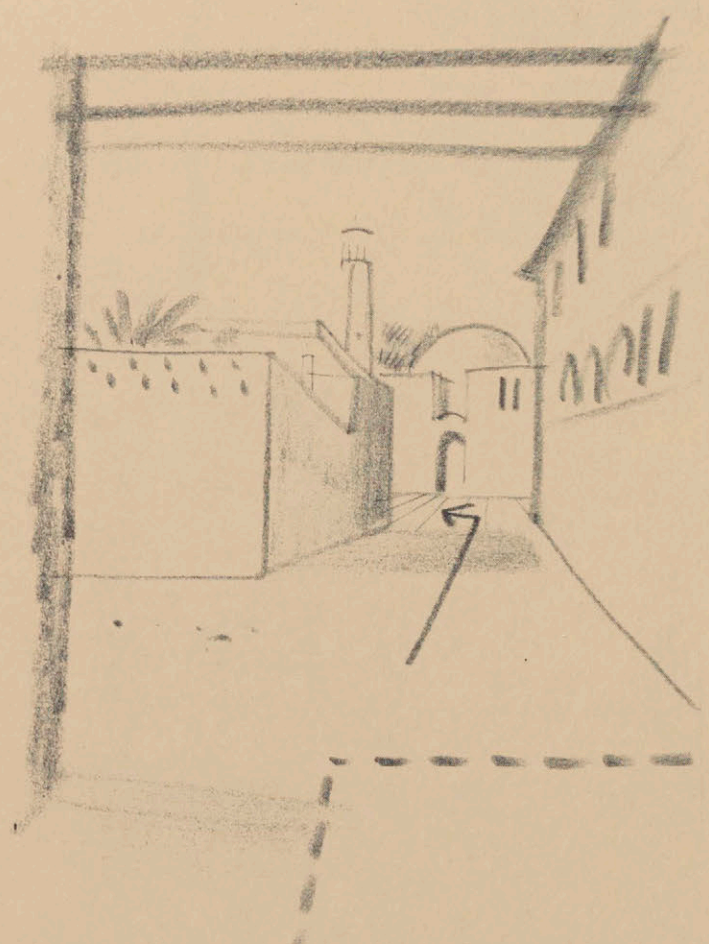


e From the local centre a major pedestrian route leads towards the neighbourhood centre. Intersections with smaller streets create small spaces, where a small corner shop might open (f)

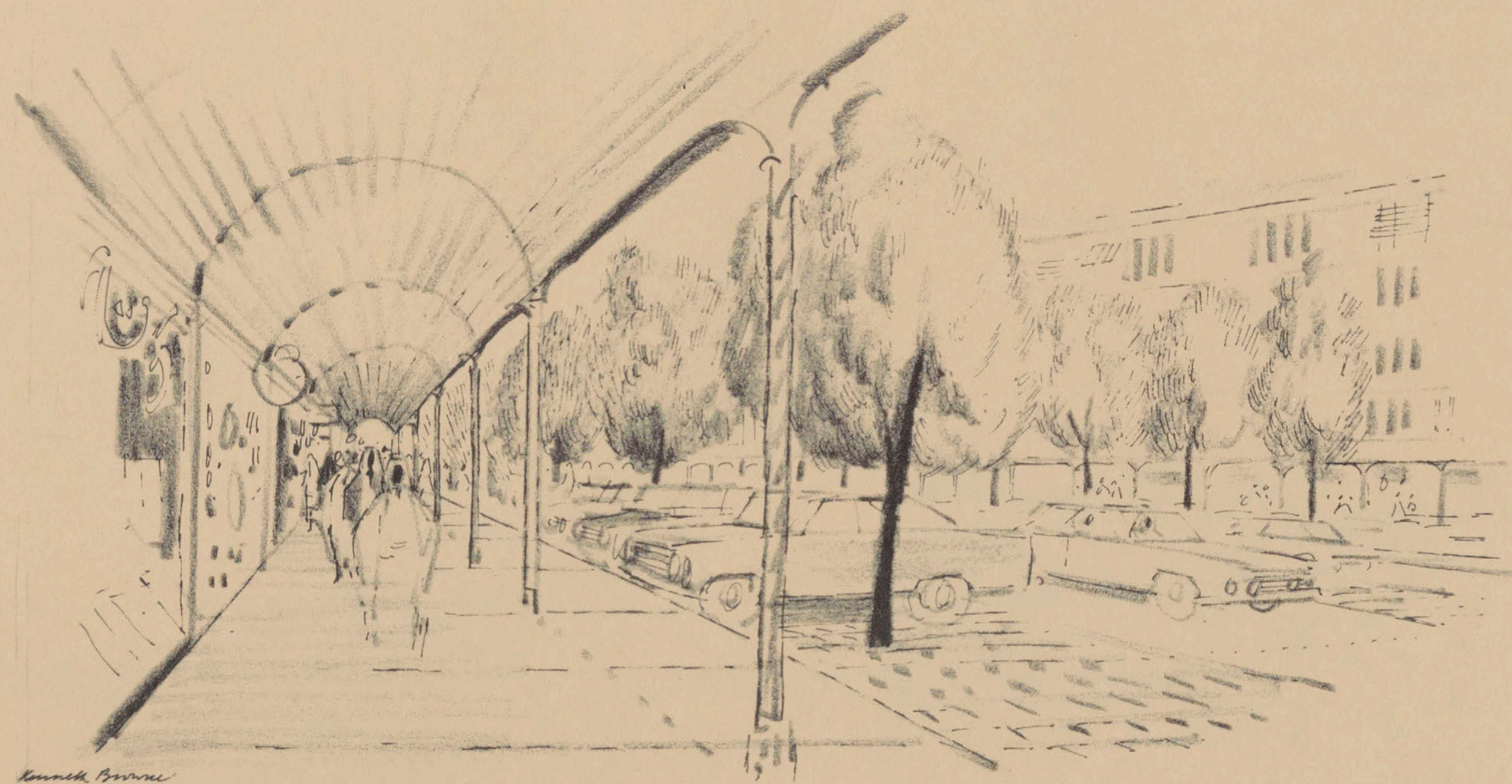
h Looking back across a pool and fountains to the mosque.



i · Main square



g The pedestrian route bends around a nursery school and a major mosque into the central square of the neighbourhood.



j The tree lined avenue of the neighbourhood high street.

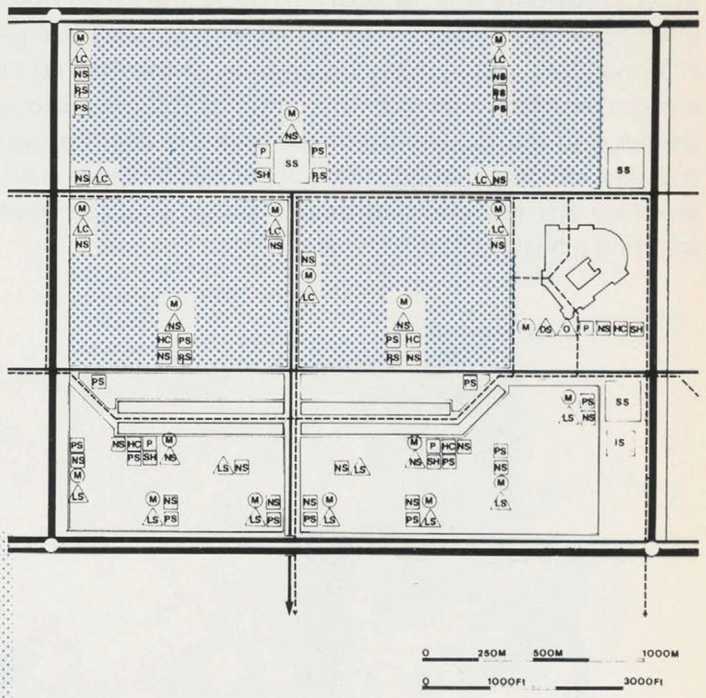
Higher income residential areas

The density of these areas will be relatively low and greater reliance on the private car, taxi, and to a lesser extent public transport can be anticipated. The relatively low numbers of families with children of school age and of elderly people, especially during the Town's first 10 years, will necessitate a greater distance between home and school and other social facilities than experienced in the low income Neighbourhood. A greater dependence on the District Centres and Town Centre can also be expected.

A certain amount of self selection will take place as people with children of school age will tend to buy houses within easy journey distance of the schools.

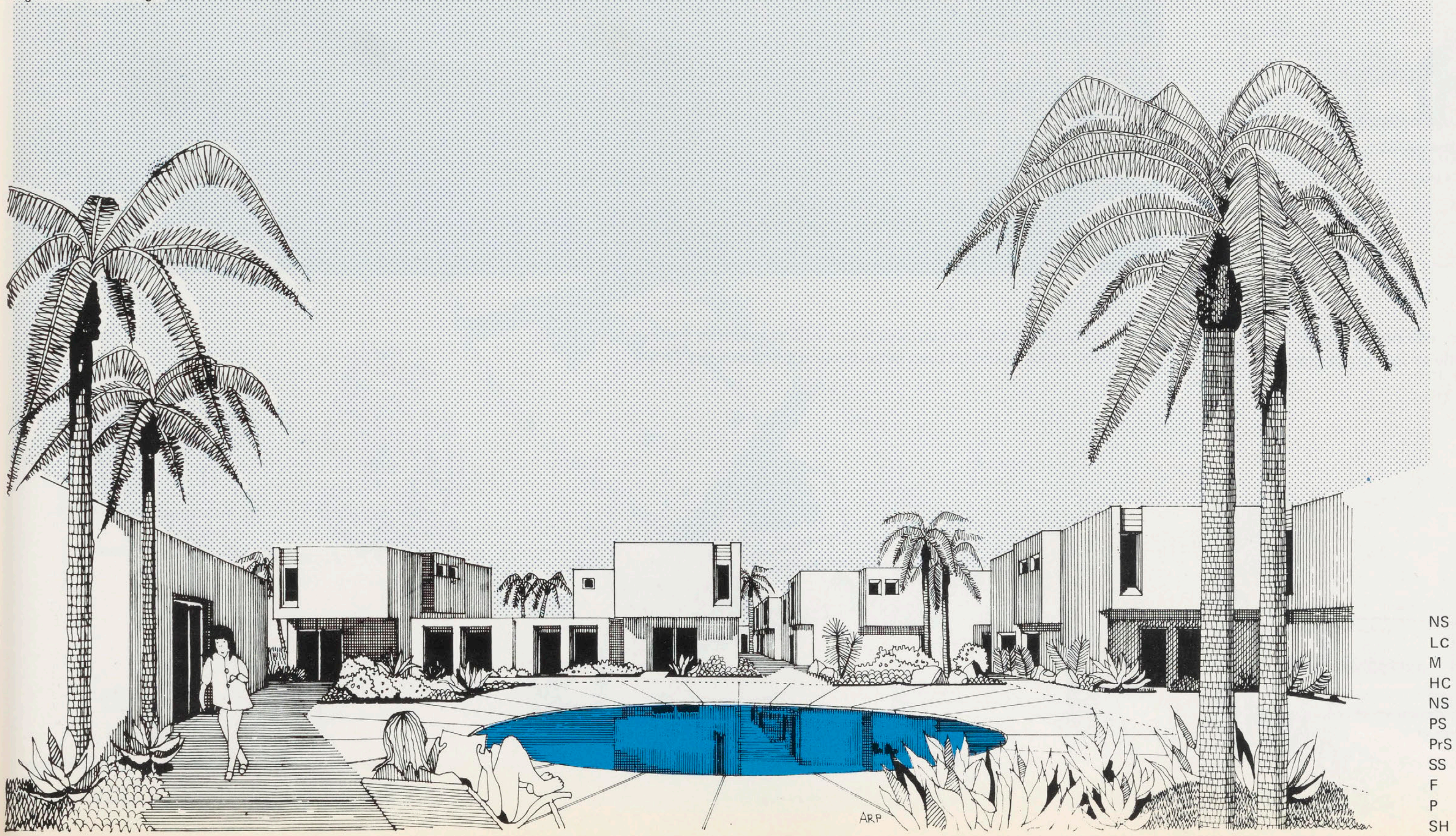
This factor argues for a concentration of facilities into local centres, leaving the more mobile members of the town to travel the greater distances. But even so, no house will be more than 500 metres away from the Neighbourhood or Local Centre, figure 25. As wide a range of housing choice as possible should be provided to combat the possibility of regimentation of layout and standardisation of house design that could otherwise result from the need to construct dwellings at the speed required to meet the town's development programme.

Emphasis must be placed on the provision of recreation and amenity facilities within the housing areas. The enjoyment of living here could be appreciably enhanced if houses were grouped around small parks containing swimming pools, tennis courts and shaded by extensive tree planting



NS	Neighbourhood Centre
LC	Local Centre
M	Mosque
HC	Health Clinic
NS	Nursery School
PS	Primary School
PrS	Preparatory School
SS	Secondary School
F	Fire station
P	Police station
SH	Sports hall

High income housing



Chapter 10
Landscaping

28
Landscaping

landscape buffer

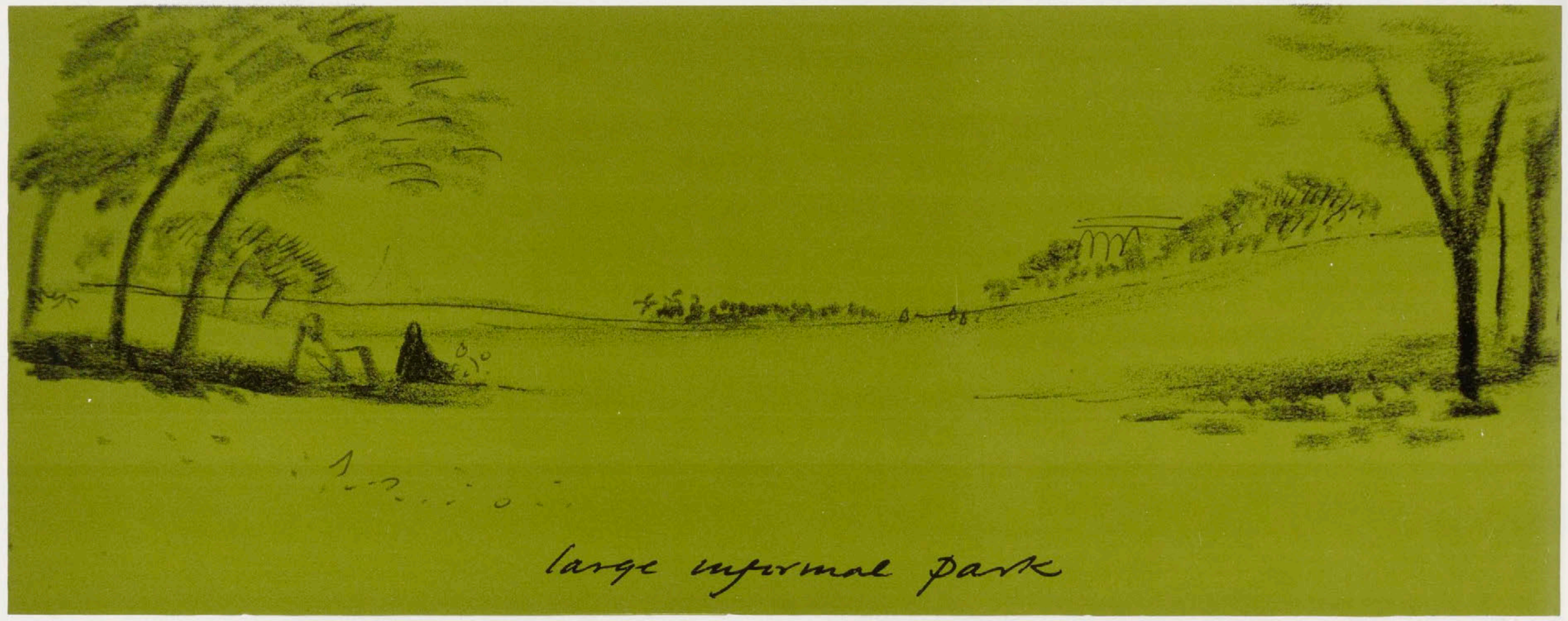
district parks
Neighbourhood parks
Local centre parks

landscaped avenues

Environmentally it is necessary to break the urban mass with open spaces, town squares and parks. The extensive plant and tree growth in Dubai's National Park and in many other areas of the Emirates lends weight to the recommendation that extensive areas of the town should be landscaped. The studies into the availability of the requisite engineering services for the town strongly indicate that adequate water can be made available from treated sewerage effl uent and that treated sludge could be used for compost, thus ensuring a health plant growth.

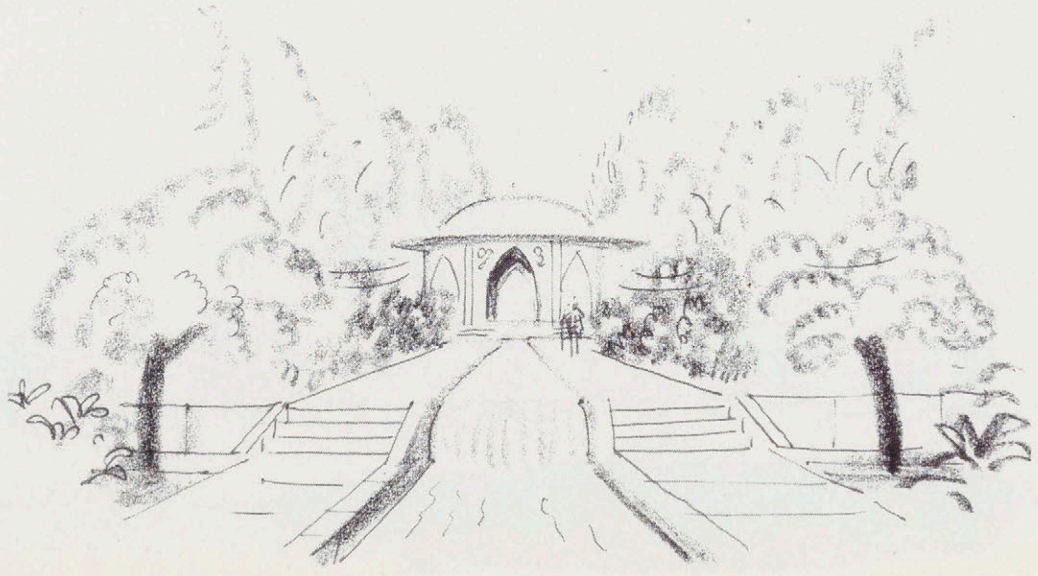
small town park

The large informal park
Extensive landscaped areas are proposed in the Town and District Centres for leisure and recreational activities. These will be places to walk, sit or play amongst tree lined avenues. The parks, will provide a contrast to and relief from, the urban nature of the town and the harsher climate of the desert outside.

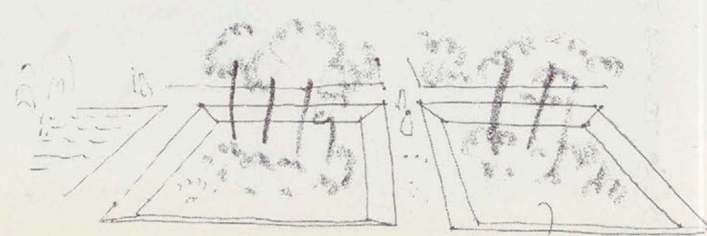


The small formal square
Small, formal landscaped parks throughout the town, will provide quiet refreshing backwaters aside from the hustle and bustle of its busiest places.

Water
Sufficient quantities of non-potable water will be available for fountains, pools and canals, which could be used extensively throughout the Town.



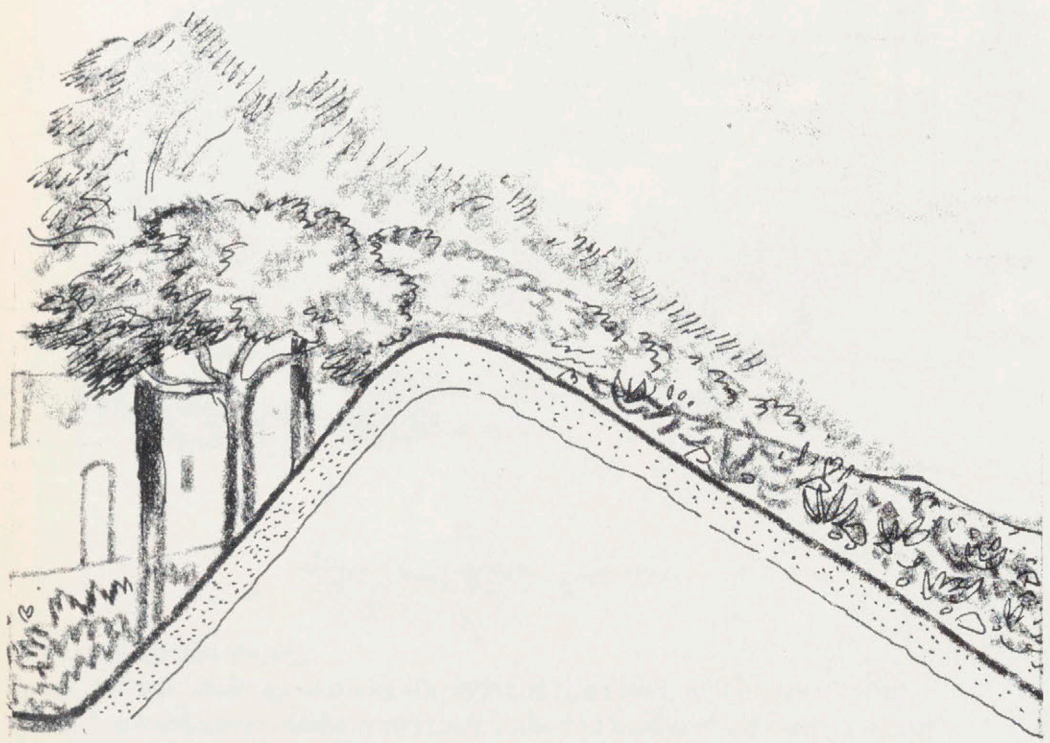
water garden



Sunken garden


TO ABU DHABI
TOWN CENTRE
TO ABU DHABI
INDUSTRIAL ZONE
ship repair yard
offshore engineering construction
PORT
dubal
ferrostaal
sunningdale gas plant
ferrostaal steel works
labour camp
dubai aluminium smelter
power station
TO DUBAI
reservoir
JEBEL ALI
wadi
INDUSTRIAL ZONE
INDUSTRIAL ZONE
FREE ZONE LINK
INDUSTRIAL ZONE
INDUSTRIAL ZONE
TO JUMEIRAH
TO DUBA
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
0 1 2 3 miles

Wind break
The sand dunes advance generally from the south west, the direction of the most consistent and strongest land breeze. A linear sand dune barrier is therefore proposed along the western edge of the town, which together with general land clearance, should do much to improve the micro limate within the town. The barrier must be about five metres high in order to lift the wind, and extensive planting and the use of clay and rocks will be required stabilisers.



Windbreak

Separation strips
Landscape areas are shown separating and protecting residential areas from major roads or industrial areas. Spaces between residential districts are also proposed to create a greater feeling of intimacy for each and to provide space for major schools and recreational areas.

<.... separation strip .... >

Boulevards and avenues
Tree lined roads, such as the neighbourhood high street, will do much to soften the townscape, and bring colour and shade to the streets.

road with planted central reservation
tall trees in centre – lower. shade trees on sides.

Tree lined Avenue with fountain
as focal point

Chapter 11
Implementation and control

Implementation
The urban development process must be integrated so that the responsibility for planning and design is not separated from implementing and managing that development.

Development agency
It will be for His Highness, the Ruler, to determine the best arrangement to ensure the successful development of the town and a critical requirement he will of necessity consider is the establishment of a development agency to focus the various requirements of a rapidly developing community and to act as a catalyst for investment by others. One of its major tasks will include the provision of strategic services e.g. water, sewerage and communications, either through its own investment activities or those of external agencies. It will ensure the provision of local infrastructure in pace with the required development programme and in appropriate cases negotiate the disposal of land for a variety of development uses. Its major objective will be the creation of a pleasant and stable environment in which a variety of immigrants will wish to settle with their families.

An early requirement will be the designation of land and boundaries of the site for the new town (if not already so designated). Such designation order will determine the purpose for which the land can be developed and indicate any conditions that will be attached to its disposal to or by the principal development agency.

Land tenure
Flexible market policies for the disposal of land will have to be evolved to meet the demands of a rapid development programme. Disposal terms should clearly aim at recovering the initial cost of land and the provision of infrastructure. An objective worthy of consideration is the retention where possible of the increment in land value for the benefit of the community as a whole, particularly when a major programme of social services is contemplated.

Development finance
The finance for development will arrive from a number of different sources and it would be prudent to determine the role of both public and private sectors in this respect. Public agencies responsible for social service provision will no doubt require some broad indication of the level of investment required throughout the period of development; for this purpose broad cash flow requirements for the whole development would be well worth calculating initially and up-dated as the development of the town proceeds.

Industrial promotion
The development of the town will depend to an important extent on the attraction of industry additional to the basic industries already specified in the development plan. Attractive sites will have to be developed with a variety of tenures and of differing size to meet the wide spectrum of demand likely to arise. A flexible marketing policy for land will be a strong necessity and may well extend into the provision of factory and warehousing space for disposal in order to attract the wide range of industrialists that will be necessary to achieve a balanced and buoyant economy.

Attracting the workforce
An adequate flow of workers is vital if the needs of industry are to be met and the pace of development maintained. In addition to the provision of adequate housing and other support facilities the agency for development should aim to co-ordinate the labour requirements of the various industries and assist in every possible way the efforts of the various employers to attract an adequate supply of labour.

Future maintenance
The efficiency of management and maintenance of the completed development is an important item for discussion as a corollary to the efficiency of the programme for implementation.

Phasing
The economic phasing of development is an important facet of any successful programme and a phasing plan for both physical and social-infrastructure is a necessity. The key objective is to ensure that services are provided marginally ahead of demand but not so far ahead as to create economic and financial difficulties.

Construction industry
Many development programmes fail through the inadequacy of the construction industry to perform at the pace required. As the pace of development is a critical aspect in Jebel Ali, early consideration must be given to the adequacy of the local construction industry, the availability of materials and the building methods to be adopted in order to ensure a continuous programme.

Control
The plan established a framework for growth but a vital factor in planning is time. It is a fundamental axiom that a Master Plan devised to cover a long time span should be constantly under review. The planning process must be accepted as never ending. The Plan is thus not a static instrument, but a dynamic, changing and growing mechanism sensitive to the changing needs of the community.

Two forms of control are required:
1 A continuing monitoring system to indicate whether or not the plan is being realised and whether change is needed.
2 A design control system to ensure that activities locate in the right place, in the right manner and that a high standard of environment is being achieved.

Monitoring system
This should record differences between planned and actual achievement in construction, and it should assess the fitness of the plan according to current and anticipated requirements of the government and industry. Major reviews will need to be carried out every five years or to coincide with any major Government Policy that would affect Jebel Ali.

The mainstay of the monitoring system would be simple card index recording every building use and floor area. The system must be capable of computer handling.

Development Control

A control system related to the allocation of land will be required. The sizes of plots is important, for example to allocate a small plot of land in a position that requires a building of substance would do irreparable harm to the town's composition. It is also essential that development is implemented to a cohesive pattern. Haphazard development will be expensive to service and will not make the best use of the scarce reserves in manpower and building materials.

The detailed design studies for the town are correlated into a land use policy map which defies the uses and densitites appropriate to areas of the Town. The Town Centre and activity spine are accorded the highest densities. A mixture of use would be appropriate such as flats, hotels, shops, offices, public buildings, places of assembly, restaurants, together with the necessary social, service and amenity facilities.

To control the quantity of building that could be accommodated within an area, a site coverage factor has been used. The factor expressed as a plot ratio clearly sets down the total building area allowed on a plot. We have recommended a range of standards, but these will be required to be examined in greater detail by the Development Agency. The Town Centre enjoys a plot ratio of 3.5 : 1 so that if the building plot measures 100 feet x 100 feet the total building must not be greater than 35,000 sq. feet. The area is measured over external walls but should exclude covered car parking area and plant space used to accommodate the mechanical services for the building. The plot ratio requirement is related to the capacity of the road network, the provision of infrastructure and social service and school provision etc. To exceed the allocation could cause overloading of the towns support system. The activity spine has a lower plot ratio of 2:1 but the District Centre would be built to a 3:1 plot ratio.

All residential areas, outside the mixed use zone of the centre, are controlled by a density allocation related to the net residential site. Net residential site area, is defined as the building site including incidental open space and half the width of the adjacent residential roads. Where the site bounds open space a width of 20 feet could be taken in lieu of the road space allocation. A range of residential densities are suggested to take account of the greater compactness of the buildings in the low income areas and the greater use of private cars and the demand for more generous space standards in the high income areas.

Conclusion

Creative town planning can only be successful if the aims and goals and aspirations are clearly stated. In this report we have developed a framework for the growth of the Jebel Ali New Town, which will determine the appearance and the relationship of each neighbourhood to its district and each district to the town centre, and also underlines the interdependence of the residential growth to the industrial development. It now remains to translate this framework into a reality.

We strongly recommend that a start should be made on the central areas of the Town Centre, and that their development should be carried out on a very substantial scale as one architectural concept to generate the excitement and vitality that should be experienced at the heart of the Town, and to give it an identity and sense of place.

An equally important aspect of the proposals is the realisation that the effect the climate has on the social life of the Town cannot be simply resolved by technical innovation such as mechanical air conditioning. Full provision must be made to provide an attractive environment in the form of squares, courts, avenues, recreational areas and markets for its inhabitants, not only to enhance its visual appearance, but also to provide acceptable conditions in which to live and work. Furthermore, a town offering excellent commercial and recreational facilities will play a significant role in attracting prospective industrialists.

The translation of Jebel Ali New Town from idea to reality has begun with the construction of the harbour and represents an historic landmark in the evolution of Dubai and will ensure that it maintains its pre-eminence as one of the principal trading centres in the Gulf.

Appendix

4

Appendix A
Climatic conditions

Table 1

Percentage annual frequency of surface wind speed and direction recorded at Dubai International Airport

Knots	N	NE	E	SE	S	SW	W	NW	All Directions
Calm									5.5
1– 3	0.9	1.6	2.8	2.8	2.6	0.6	0.4	0.6	12.3
4– 6	2.6	4.0	4.3	5.6	8.2	2.4	3.3	3.0	33.4
7–10	2.3	1.9	2.0	3.3	5.7	1.6	8.2	5.2	30.2
11–16	2.0	0.4	0.6	0.6	1.1	0.7	6.2	4.5	16.1
17–21	0.3	0.1		0.1	0.1	0.1	0.7	0.3	1.7
22–27					0.1		0.1		0.2
All Speeds	8.1	8.0	9.7	12.4	17.8	5.4	18.9	13.6	99.4

Table 2

1975 Climatic data recorded at Dubai International Airport

Month	Rain	Mean Monthly Max. Temp. °C	Mean Monthly Min. Temp. °C	Absolute Max. Temp. °C	Absolute Min. Temp. °C	Relative Humidity % Mean Monthly Max.	Relative Humidity % Mean Monthly Min.	QBI Fog/Mist Total Hr.Min	QBI Dust/Sand Total Hr.Min	Atmospheric Pressure Millibars
Jan	42.7	23.8	12.9	28.9	9.2	89	49	58.20	38.05	1018.9
Feb	26.8	24.3	14.5	30.5	9.5	88	46	35.20	15.45	1017.5
Mar	Trace	28.5	16.2	38.1	10.1	81	32	11.00	64.00	1014.5
Apl	5.3	31.7	19.0	37.5	12.8	80	32	16.15	51.20	1011.4
May	Nil	38.1	22.9	43.1	19.7	78	25	39.30	80.00	1004.9
Jun	Nil	38.5	25.4	47.2	20.7	88	38	112.05	132.35	998.4
Jul	Trace	41.7	29.2	46.5	26.9	81	36	43.00	186.10	997.5
Aug	0.4	40.1	29.3	45.8	25.9	80	40	41.05	177.35	997.8
Sep	Nil	40.5	25.1	43.6	23.0	87	27	86.35	88.50	1004.4
Oct	Nil	34.3	20.8	39.9	14.6	81	37	17.15	9.30	1010.5
Nov	Nil	30.3	17.4	33.0	14.3	85	42	25.00	27.50	1016.4
Dec	Nil	26.4	14.1	27.8	9.4	86	45	23.30	28.35	1018.7

Yearly Rainfall Total		= 75.2 mm
Yearly QBI Total	Fog/Mist	= 508.55 (Hr.Min)
	Dust/Sand	= 900.15 (Hr.Min)
Yearly Mean Maximum Temperature		= 33.2°C
Yearly Mean Minimum Temperature		= 20.6°C
Yearly Absolute Maximum Temperature		= 47.2°C
Yearly Absolute Minimum Temperature		= 9.2°C
Yearly Mean Maximum Rel. Humidity		= 84%
Yearly Mean Minimum Rel. Humidity		= 37%
Yearly Mean Sea Level Pressure		= 1009.2 mb

Table 3

Percentage of wind directions

Year	Month	N	NE	E	SE	S	SW	W	NW	Calm
1975	Jan	5.2	13.3	8.4	13.2	21.3	3.6	21.7	8.4	4.4
	Feb	11.1	13.1	10.7	8.9	14.7	1.8	18.2	12.8	8.0
	Mar	6.8	6.0	10.8	11.6	16.5	4.0	27.4	12.0	4.4
	Apr	11.2	6.2	10.8	8.3	17.1	7.5	18.7	16.9	2.9
	May	7.6	3.2	7.2	14.4	20.9	8.4	19.0	17.7	1.2
	Jun	3.3	3.3	6.6	10.0	31.6	7.9	20.3	15.9	0.8
	Jul	20.1	8.4	17.2	10.0	12.5	3.6	7.2	17.8	2.8
	Aug	14.8	10.0	16.8	11.2	9.6	6.8	10.0	16.8	3.2
	Sep	17.5	8.7	17.0	7.0	16.3	2.4	5.4	17.7	7.5
	Oct	8.0	7.6	11.2	15.3	15.8	2.8	16.1	15.7	7.3
	Nov	10.3	6.2	10.4	12.0	25.3	2.9	14.6	10.9	7.1
	Dec	10.4	10.0	13.2	12.1	17.0	3.2	13.7	12.5	7.7
1976	Jan	8.4	4.4	8.4	10.4	27.4	1.6	27.0	8.0	4.0
	Feb	11.1	15.4	14.5	11.5	13.9	5.6	18.5	6.1	3.0
	Mar	17.3	11.2	10.4	6.0	8.8	6.0	16.4	14.4	8.8
	Apr	5.8	6.2	8.3	9.5	20.3	8.7	23.7	10.9	6.2
	May	3.2	1.2	4.4	9.2	31.7	10.8	28.8	6.0	3.2
	Jun	8.3	3.3	2.0	12.1	25.8	14.1	20.0	10.5	3.8
	Jul	6.0	3.6	3.6	6.0	28.6	12.5	24.1	12.1	3.2
	Aug	11.2	3.6	10.4	14.0	19.3	4.0	15.6	18.0	3.2
	Sep	14.6	7.1	9.9	11.2	12.5	5.1	8.7	22.5	8.3

Table 4

Percentage of wind speeds (knots)

Year	Month	Calm	01-03	04-06	07-10	11-16	17-21	22-27	28-33	33
1975	Jan	4.4	18.4	35.0	28.1	11.6	1.6	0.4	–	–
	Feb	8.0	16.0	37.5	26.2	9.2	2.2	0.4	–	–
	Mar	4.4	12.8	30.1	24.9	21.7	5.2	0.4	–	–
	Apr	2.9	12.1	35.3	25.4	20.3	3.6	–	–	–
	May	1.2	12.0	24.0	37.4	22.2	2.4	0.4	–	–
	Jun	0.8	3.6	20.8	48.7	25.4	0.4	–	–	–
	Jul	2.8	4.0	32.9	29.0	26.5	4.4	–	–	–
	Aug	3.2	6.8	30.0	32.0	23.2	4.0	–	–	–
	Sep	7.5	9.5	30.2	28.6	23.3	0.4	–	–	–
	Oct	7.3	12.0	34.2	33.0	13.3	–	–	–	–
	Nov	7.1	6.9	40.0	32.9	12.8	–	–	–	–
	Dec	7.7	10.8	37.0	32.7	10.8	0.8	–	–	–
1976	Jan	4.0	13.2	33.4	34.9	14.1	–	–	–	–
	Feb	3.0	12.9	24.4	36.1	20.2	2.6	0.4	–	–
	Mar	8.8	15.2	26.4	28.4	18.1	1.6	0.8	–	–
	Apr	6.2	20.0	33.3	27.9	10.6	1.2	0.4	–	–
	May	3.2	18.0	37.6	33.7	6.0	–	–	–	–
	Jun	3.8	20.8	34.9	33.3	7.1	–	–	–	–
	Jul	3.2	12.0	37.00	39.5	8.0	–	–	–	–
	Aug	3.2	22.8	36.5	25.2	11.2	0.4	–	–	–
	Sep	8.3	31.2	25.5	28.7	6.2	–	–	–	–

Table 5

Wind speed interpretation

Beaufort Scale Force	Speed in Knots	Subjective Description
0	0– 1	Calm
1	1– 3	Light Air
2	4– 6	Light Breeze
3	7–10	Gentle Breeze
4	11–16	Moderate Breeze
5	17–21	Fresh Breeze
6	22–27	Strong Breeze
7	28–33	Near Gale
8	34	Gale
9		
10		
11		
12		

At Force 6 walking becomes somewhat difficult, building damage begins to occur at Force 9, with tiles being blown off, at Force 11 buildings are destroyed, whole woods uprooted, men and animals may be lifted and carried.

Appendix B
Population and employment projections

The method used to determine the population estimates for Jebel Ali comprised stages:—

1. the estimation of employment in the industrial base;
2. the establishment of the relationship between the industrial base employment and total employment;
3. the production of global population estimates based upon activity rate assumptions;
4. the phasing of the population growth according to realistic rates of construction.

INDUSTRIAL BASE EMPLOYMENT PROFILE

↓ Relationship between the industrial base and total employment

TOTAL EMPLOYMENT PROFILE

↓ Proportion of population assumed to work

TOTAL POPULATION PROFILE

↓ Rate of job creation, and dwelling construction

POPULATION PHASING

Industrial base employment estimates

Current plans provide for the construction of the following industrial base in Jebel Ali:—

1 A port complex of 75 berths and facilities to meet the demands of industry associated with Jebel Ali.

2 A two runway airport to function both for passengers and cargo.

3 Aluminium smelting plant, and extrusion plant.

4 Liquified petroleum gas plant.

5 Power Station.

6 Steelworks of 500,000 tons per annum output.

It is also proposed to relocate all construction work for oil and gas production to Jebel Ali.

Further plans propose the construction of a Free Trade Industrial Zone for light industries, an oil refinery, and a petro-chemical complex.

We have taken the above industrial project as the employment base of Jebel Ali, and have assumed that with the exception of the Free Trade Industrial Zone, all would be substantially complete by 1985. Employment levels within each enterprise were initially estimated for this date. Where possible direct contact was made with the prospective occupiers, and employment estimates by occupational status were made for the heavy industrial base and the construction companies. No firm statistics were available regarding the levels or compositon of employment in the airport, the port, the steelworks, or the Free Trade Industrial Zone. Accordingly assumptions were made regarding typical employment structures in the United Kingdom and in other Middle Eastern States which were scaled to the known output or dimensions proposed in Jebel Ali. For the Free Trade Industrial Zone we have assumed that 20,000 people would be employed by 1985, based upon a gross employment density of 41 persons per hectare.

The resulting breakdown of the industrial employment is shown in Table 1.

Table 1

Industrial base employment Jebel Ali 1985

Industrial Category	Management professional & technical	Supervisors skilled manual foremen & office	Semi and unskilled manual & office	Total
Port and airport	1200	5800	6200	13200
Heavy industry	300	1400	1300	3000
Oil & petrochemicals	650	3900	3850	8400
Light industry & warehousing	1500	5400	13100	20000
Public utilities	450	1400	3150	5000
Total	**4100**	**17900**	**27600**	**49600**

Estimates were made for the intermediate date of 1981, by assuming certain levels of operation for each industrial occupier. It was considered realistic to assume that the aluminium smelting and extrusion plants, the gas plant, the power station, and the steel works would be substantially complete by 1981, and would have achieved their design employment levels. We have further assumed that the relocation from Dubai of the construction work for oil and gas production will be complete by 1981. For the light industry we have assumed an employment of 5,000, the public utilities 2,000, the airport 2,500 and the port 4,000.

Applying to each industry the occupational breakdown adopted for the 1985 estimated employment levels, Table 2 illustrates the resulting employment structure predicted for 1981.

Table 2

Industrial base employment structure 1981

Industrial Category	Management professional & technical	Supervisors skilled manual foremen & office	Semi and unskilled manual & office	Total
Port and airport	700	3000	2800	6500
Heavy industry	300	1400	1300	3000
Oil & petrochemicals	200	1350	1450	3000
Light industry & warehousing	350	1350	3300	5000
Public utilities	200	550	1250	2000
Total	**1750**	**7650**	**10100**	**19500**

Post 1985 growth of the industrial base is far more difficult to predict, and a range of estimates were produced for the design date representing the continuing growth of the committed industry, and further expansion of the light industrial sector. We concluded that by 2007 it would be possible that between 70,000 and 125,000 further jobs could be created mainly in light manufacturing and warehousing, after 1985. Although the estimates are not totally light industrial and warehousing employment, they were based upon the assumptions of gross employment densities of 20 persons per hectare (to arrive at the lower estimate), and 36 persons per hectare for the higher figure. The former case represents a strong bias towards warehousing, and other capital intensive activity.

Accordingly two estimates of industrial base employment were produced for 2007, 119,500 and 172,100. It was considered that the lower target was more realistic in terms of net job creation possibilities, and hence further detailed work was orientated towards the 119,500 industrial base employment.

To estimate the occupational breakdown of these estimates for 2007, we adopted the assumption that the same proportional division applicable in 1985 would remain constant throughout the period. The resulting summarised breakdown is produced in Table 3.

Table 3

Industrial base employment 2007

Projection	Management professional & technical	Supervisors skilled manual foremen & office	Semi and unskilled manual & office	Total
High	13300	50900	107900	172100
Low	9400	36700	73400	119500

Construction Employment

We take the construction employment category as separate from both the industrial base predictions, and those of service employment. Because of the itinerate nature of such employment we have estimated a 'hard core' of the construction workforce of approximately 11,000 people. These we feel will be resident in the town throughout the Master Plan period and beyond, but only a proportion of the workforce will require housing accommodation and accordingly contribute to the resident population of the town. The remaining workers will most certainly be accommodated in temporary buildings on the construction sites themselves.

Although we have adopted a constant level of construction employment for the Master Plan period we must accept, depending upon the rate and nature of construction activity, that at times (particularly during the early stages of development) the total construction workforce will be far greater and could possibly reach 24,000. Nevertheless we have taken the 11,000 estimate as the basis upon which the construction labour force is included in the total town population.

The typical breakdown amongst occupational categories assumed was based upon United Kingdom statistics modified to Middle Eastern standards. The resulting estimates of shown in Table 4.

Table 4

Occupational breakdown — construction labour force

Professional, Technical and Management	850
Supervisors, Foremen, Skilled manual and office workers	3500
Semi and Unskilled manual and other workers	6650
Total	**11000**

Service Employment Estimates

The present characteristics of towns in the Middle East to have a high service employment to industrial employment ratio, sometimes of the order 70 : 30, was an unrealistic assumption, at least in the short term, to adopt for Jebel Ali. The aim for Jebel Ali to be primarily an industrial town, in contrast to Dubai as an administrative/commercial town, strengthens the conclusion that the levels of service employment likely in Jebel Ali will be lower than is typical.

We have adopted the assumption that up to 1985 the service to industrial base ratio will be 40 : 60. Thereafter we have assumed a linear increase in this ratio to reach 50 : 50 by the year 2007. At this stage construction employment has been excluded from the calculations. Our assumptions imply a rising proportion of dependent population resulting from an increase in the migration of family population as opposed to single worker migrants during the post 1985 period. Nevertheless it is by no means certain that such migration will occur; and we have therefore also examined the implications of holding the service to industrial base employment ratio constant at 40 : 60, the 1985 level.

In the previous section we have argued for two industrial base employment levels for 2007 and applying the above assumptions regarding the service to industrial base ratios we produced three service employment estimates for 2007, but only one for the period up to 1985. Table 5 reproduces the resulting figures.

Table 5

Service employment estimates

Date	Service Employment
1981	13000
1985	33000
2007 – High	172100
– Medium	119500
– Low	79500

For each of these estimates, the occupational breakdown was postulated through the application of modified assumptions derived from available statistics both in the Middle East and Western Europe. Basically we have implied that 17% of the total service employment will be management, professional or technical workers, 24% supervisors, foremen, skilled manual and office workers, and 59% semi and unskilled manual and office workers. The resulting figures are shown in Table 6.

Table 6

Service employment – Occupational breakdown

Date	Management professional & technical	Supervisors foremen, skilled manual & office	Semi and unskilled manual & office	Total
1981	2200	3100	7700	13000
1985	5600	7800	19600	33000
2007 – High	29300	40400	102400	172100
– Medium	20300	28100	71100	119500
– Low	13500	18700	47300	79500

Total Employment Estimates

The addition of the estimates of industrial base, construction and service employment produced total employment estimates for Jebel Ali, in 1981, 1985 and 2007. Three estimates resulted for 2007, but one will suffice for the period up to 1985. Table 7 illustrates the projection.

Table 7

Employment projections, 1981–2007

Date	Total Employment
1981	43500
1985	93600
2007 – High	355200
– Medium	250000
– Low	210000

Table 8

Total employment – Occupational breakdown, 1981–2007

Date	Professional Managerial & technical	Supervisors, Foremen skilled manual & office	Semi and unskilled manual & office	Total
1981	4800	14250	24450	43500
1985	10550	29200	53850	93600
2007 – High	43450	94800	216950	355200
– Medium	30550	68300	151150	250000
– Low	23750	58900	127350	210000

To use the total employment structure as the basis for the determination of the population of Jebel Ali, we felt that some further disaggregation was necessary regarding the nationality or source of the labour force. Three categories were decreed essential, Gulf Arab population, American and European expatriates, and a broad category covering immigrants from other Arab countries and Asia. Reference was made to the existing ethnic composition of the labour force of Dubai, from which assumptions were made to apportion each occupational category employment estimates into three broad ethnic groups. Table 9 presents the resulting ethnic breakdown.

Table 9

Ethnic composition of the labour force of Jebel Ali 1981–2007

Date	Gulf Arab population	European/ American Expatriates	"Other" Immigrants	Total
1981	10500	2300	30700	43500
1985	23900	5000	64700	93600
2007 – High	93600	19400	242200	355200
– Medium	65700	13700	170600	250000
– Low	54500	10900	144600	210000

Population Projection

Using the total employment estimates, and applying activity rates to each ethnic group according to an assumed division between single person migrants and those settling with their families, the population of Jebel Ali was estimated. Table 10 summarises the resulting estimates.

Table 10

Population projections 1981–2007

Date	Resident population
1981	67600
1985	160100
2007 – High	758200
– Medium	529300
– Low	373400

These projections can be treated as a series, comprising one projection up to 1985, thereafter branching to three alternatives. Intermediate dates, post 1985 were interpolated assessing a linear trend for each series. For instance the 1996 population according to the medium projection would be 347,600.

The two stage process used to produce the population estimates, involved two broad sets of assumptions:—

(1) those relating to the proportion of each ethnic group migrating as single persons as opposed to family migrants.

(2) those relating to the percentage of the population for each ethnic group who will be working.

For both sets of assumptions we relied heavily upon data collected in Dubai, through contacts with selected employers.

In the preliminary stage, we accepted that there would be a difference in the proportion of single person immigrants to family immigrants between the construction and the other categories of employment. We assumed a much higher proportion of single person immigration for the construction workforce than for the other sectors. We further accepted that only the family population of the construction workers would be included in the town population projections. This was in contrast to the other sectors of employment from which single person workers were included in the total population estimates. Such a division was made to facilitate the housing demand analysis, — we considered that all single person construction immigrants would live in temporary accommodation on site, and hence they would not contribute to the demand for dwelling units. The other single person immigrants working in the service and industrial sectors we feel would need housing accommodation.

Table 11

Activity rates and family : non-family division of the labour force

Date	Assumptions for each employment category	Gulf Arab Population		American and European Expatriates		"Other" Immigrant Population	
		Single person immi-gration	Family immi-gration	Single person immi-gration	Family immi-gration	Single person immi-gration	Family immi-gration
1981	**Industrial Base & Service**						
	Proportion of working pop.	50%	50%	50%	50%	75%	25%
and							
1985	Activity rates	100%	20%	100%	33.3%	100%	40%
	Construction						
	Proportion of working pop.	40%	60%	75%	25%	90%	10%
	Activity rates	100%	20%	100%	33.3%	100%	40%
2007	**Industrial Base & Service**						
	Proportion of working pop.	30%	70%	30%	70%	65%	35%
	Acvitity rates	100%	20%	100%	33.3%	100%	40%
	Construction						
	Proportion of working pop.	40%	60%	75%	25%	90%	10%
	Activity rates	100%	100%	100%	33.3%	100%	100%

Note:— 2007 low projection — same as for 1981 and 1985

The specific assumptions made regarding the family and single person migration, and the activity rates adopted are summarised in Table 11.

The assumptions for 1981 and 1985 clearly reflect the largely industrial nature of Jebel Ali with a strong emphasis being given to single person immigration. The projected population is summarised in Table 12.

Table 12

Population projection, 1981 and 1985

Date	Occupational/Ethnic category	Single person Immigrant Population	Family Pop.	Total
1981	**Industrial Base and Service**			
	Gulf Arab	4400	22300	26700
	American/European	900	2800	3700
	"Other" immigrant	16300	13600	29900
	Construction			
	All Nationalities	9000	7300	16300
	Total	**30600**	**46000**	**76600**
	Total Town	**21600**	**46000**	**67600**
1985	**Industrial Base and Services**			
	Gulf Arab	11200	55900	67100
	American/European	2300	6800	9100
	"Other" immigrant	41800	34800	76600
	Construction			
	All Nationalities	9000	7300	16300
	Total	**64300**	**104800**	**169100**
	Total Town	**55300**	**104800**	**160100**

The difference between the two rows for each date representing total population reflects, in the former case the total population including the temporary house itinerate construction work-force, whilst the "total town" population excludes this section of the labour force.

For 2007, three projections were made:—

1) HIGH PROJECTION — Industrial base employment of 172,100
Service employment of 172,100
Construction employment of 11,000
An overall activity rate of 46%

2) MEDIUM PROJECTION — Industrial base employment of 119,500
Service employment of 119,500
Construction employment of 11,000
An overall activity rate of 46%

3) LOW PROJECTION — Industrial base employment of 119,500
Service employment of 79,500
Construction employment of 11,000
An overall activity rate of 54%

The first two projections represent a more family orientated town, with the associated extension of the service sector, but their difference represent the alternative assumptions as to the level of industrial base employment. The latter projection illustrates the position should the town remain a basically industrial development with limited service sector employment.

The projected population for each alternative is expressed in Table 13 and illustrated in Figure 2.

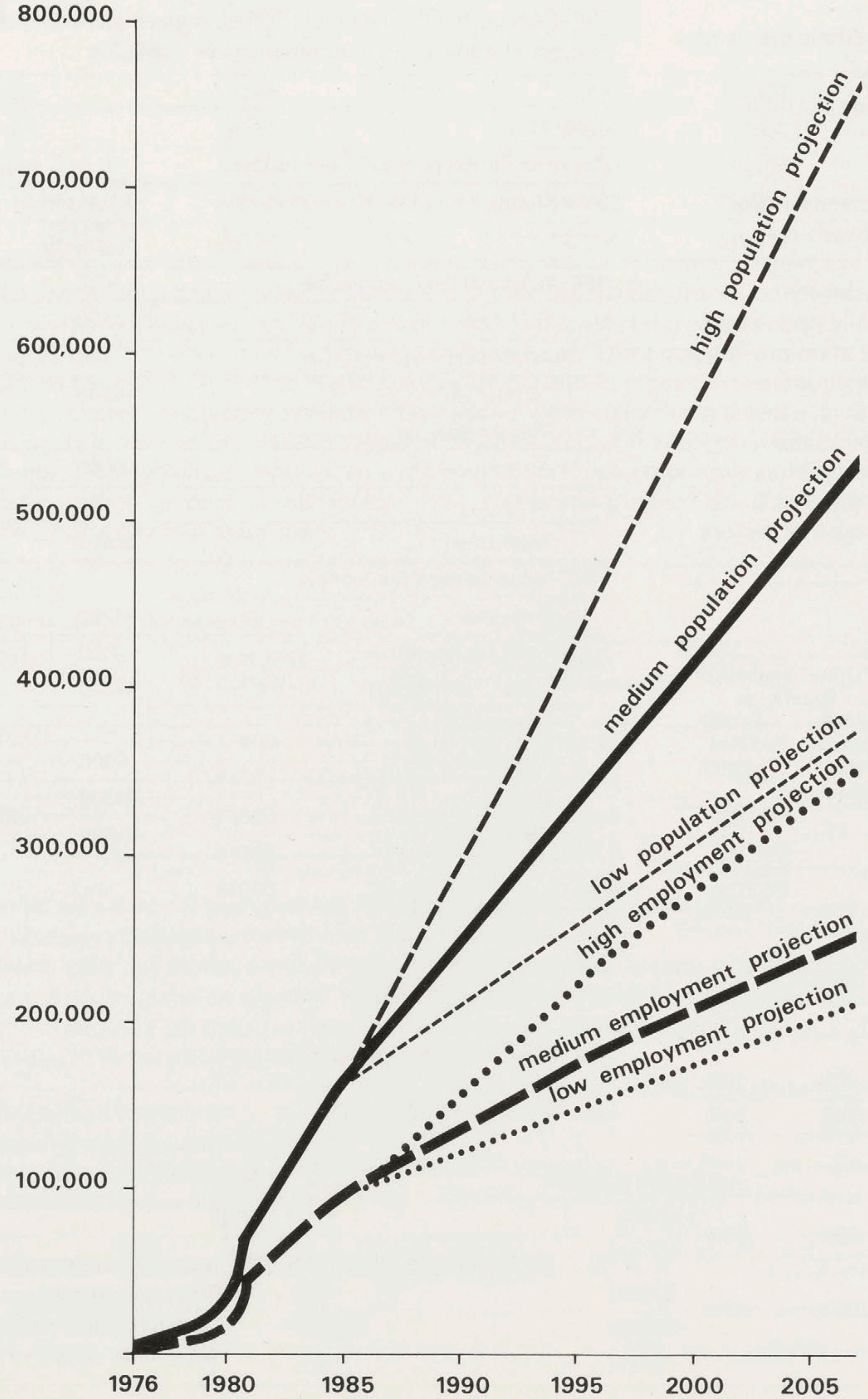
Table 13

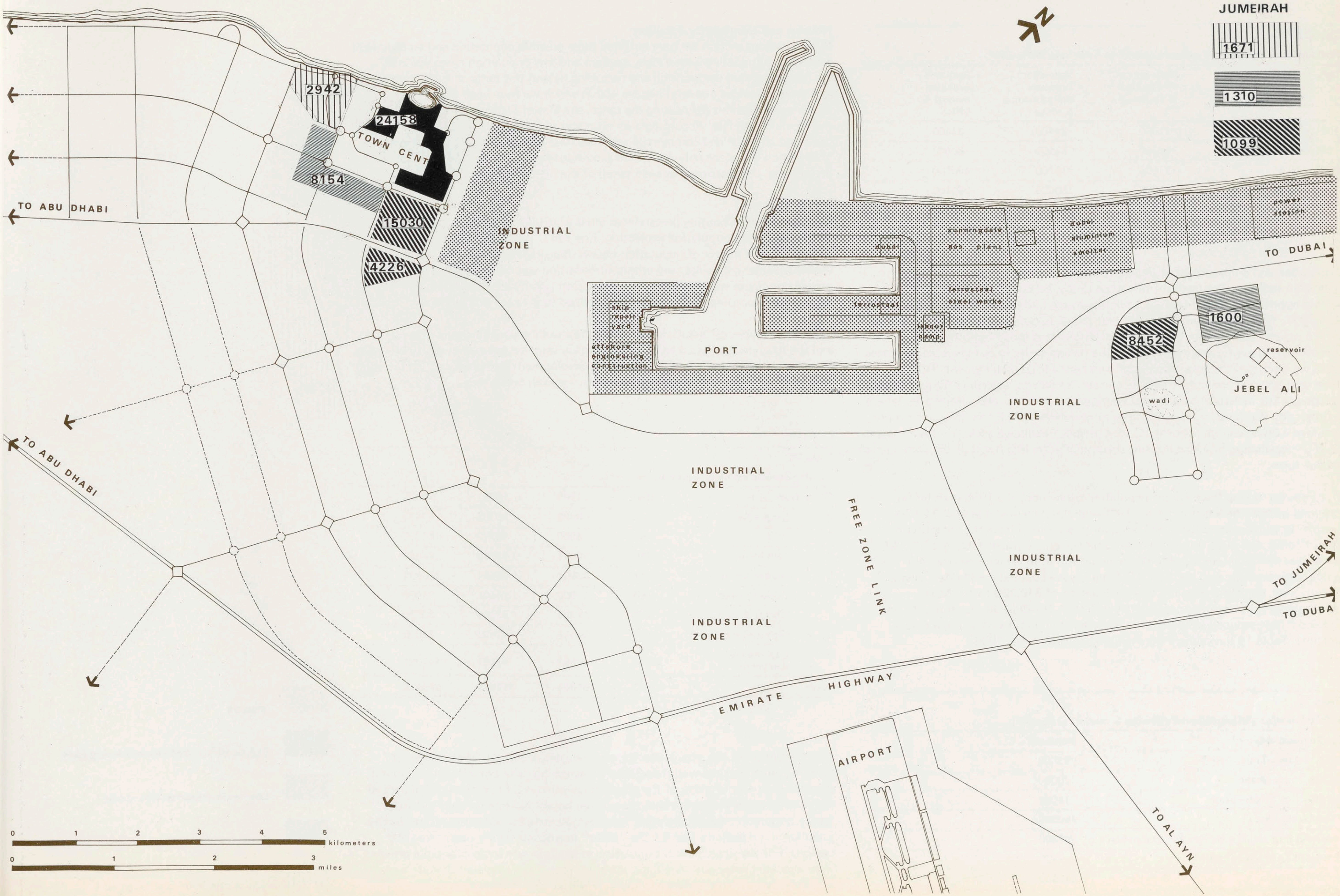
Population projections 2007

Projection	Occupational/Ethnic Category	Single Person Immigrant Population	Family Pop.	Total
High	**Industrial Base & Service**			
	Gulf Arab	27600	322200	349800
	American/European	5700	39800	45500
	"Other" immigrant	151600	204000	355600
	Construction			
	All Nationalities	9000	7300	16300
	Total	**193900**	**573300**	**767200**
	Total Town	**184900**	**573300**	**758200**
Medium	**Industrial Base & Service**			
	Gulf Arab	19300	224500	243800
	American/European	4000	27800	31800
	"Other" immigrant	105000	141400	246400
	Construction			
	All Nationalities	9000	7300	16300
	Total	**137300**	**401000**	**538300**
	Total Town	**128300**	**401000**	**529300**
Low	**Industrial Base & Service**			
	Gulf Arab	26400	132200	158600
	American/European	5200	15800	21000
	"Other" immigrant	101700	84800	186500
	Construction			
	All Nationalities	9000	7300	16300
	Total	**142300**	**240100**	**382400**
	Total Town	**133300**	**240100**	**373400**

Because the activity rates were related directly to the ethnic origin of the population and were assumed constant between each occupational category, we prepared population estimates in aggregate for each occupational category. Table 14 below summarises the results which are related to the resident town population only i.e. – they *exclude* the single person construction workforce housed in temporary accommodation.

Graph of population and employment projections





JUMEIRAH
1671
1310
1099
2942
24158
TOWN CENT
8154
15030
4226
TO ABU DHABI
INDUSTRIAL ZONE
ship repair yard
offshore engineering construction
PORT
dubal
ferrostaal
labour camp
sunningdale gas plant
ferrostaal steel works
dubal aluminium smelter
power station
TO DUBAI
1600
8452
reservoir
JEBEL ALI
wadi
INDUSTRIAL ZONE
TO ABU DHABI
INDUSTRIAL ZONE
FREE ZONE LINK
INDUSTRIAL ZONE
INDUSTRIAL ZONE
TO JUMEIRAH
TO DUBA
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
0 1 2 3 miles

30
Population 1985

Table 14

Population by occupational category of head of household 1981–2007

Date	Management Professional & Technical	Supervisors Foremen skilled manual & office	Semi and unskilled manual & office
1981	11800	24400	31400
1985	26200	53500	80400
2007 – High	137000	215700	405500
– Medium	95600	150600	283100
– Low	67500	106200	199700

Population and employment estimates 1996

The main report makes frequent reference to the 1996 situation, but these reflect hypothetical trend statisitics relating to the mid point between 1985 and 2007. They were based upon mid point total population estimates pertaining to the support population, for the industrial base and service employment. Accordingly these figures were made in the reverse order to our previous estimates. Here we estimated the total population and hence total employment. This we then split between the industrial base and service sectors according the assumptions relating to the industrial base-service employment ratio for each projection. Where a projection was based upon a changing ratio between 1985 and 2007, we simply assumed a linear change over the 22 year period. Finally we added on the constant level of population requiring housing accommodation as a result of the construction labour force.

For instance, taking the medium population projection, the 1996 population assumed midway between those for 1985 and 2007, was estimated at 340,300 people, to which was added 7,300 population generated from the construction labour force. The 1985 industrial base to service employment ratio was 60 : 40, while that for 2007 was 50 : 50. Accordingly for 1996 we adopted the mid point between these two, i.e. 55 : 45. Similarly we adopted a mid point overall activity rate, applied this to the total population of 340,300 to obtain an employment estimate of approximately 169,000. Dividing this according to the industrial base-service employment ratio, specific employment estimates were possible. Table 15 summarises the medium projections for 1996.

Table 15

1996 Population and employment estimates – medium projections

Employment category	Numbers
Industrial Base Employment	93000
Service Employment	76000
Construction Employment	11000
Total Employment	**180000**
Industrial Base and Service Resident Population	340300
Resident Construction Population	7300
Total Population	**347600**

Housing and Community Facilities

In the previous section we have outlined three possible population and employment scenarios, culminating with a high, medium and low population range for 2007. We have presented the working and reasoning behind this range in full because we feel that it provides a general picture within which we have been working. Of the three projections delineating the range, the Master Plan has been based upon the medium estimate. Accordingly all estimates of housing demand and the provision of social and commercial activities have been based on this estimate. This section therefore only deals with provisions relating to the medium population projections – no account has been taken of the higher or lower extremes.

Housing Demand

The prediction of housing demand was made possible as a direct output from the disaggregated population projection. For 1981, 1985, 2007 and the interim date of 1996, a matrix of population figures disaggregated both into occupational (hence income) groupings, and ethnic composition was constructed. Each population figure was divided into single person population, and family population according to the procedure outlined in the previous sections.

Eight house types differentiated according to dwelling densities were proposed and the fully disaggregated levels of population were assigned amongst each house type. Accordingly the schedule of housing development was produced, and is outlined in Table 16, in terms of population for each house type.

Table 16

Housing demand schedule – population

House type		1981	1985	1996	2007
A	Large villa	2416	8983	30398	47455
B	Villa	3421	8800	18997	41019
C	Family house	2399	10478	14478	26001
D	Worker family house	9960	33000	93861	156072
E	Worker shared house	4665	13000	26401	31000
F	Worker shared dormitory	3000	11398	22000	30625
G	High cost apartment	15865	24816	43990	52086
H	Low/medium cost apartment	25912	49589	97451	145057
Totals		**67642**	**160064**	**347576**	**529315**

The translation of the population for each housing group into the number of dwelling units required was undertaken by assuming different average household sizes for each ethnic group of the projected population. From the limited official statistics available it was felt that the average household size for the Gulf Arab family population was 6.0 persons, for the American/European expatriate family population 3.8 persons, and for the "other" immigrant family population 5.0 persons. For the single person population in the first two socio-economic groups were allocated individual dwellings; the third group was allocated shared accommodation. This is shown in table 17. Refer also to Appendix C.

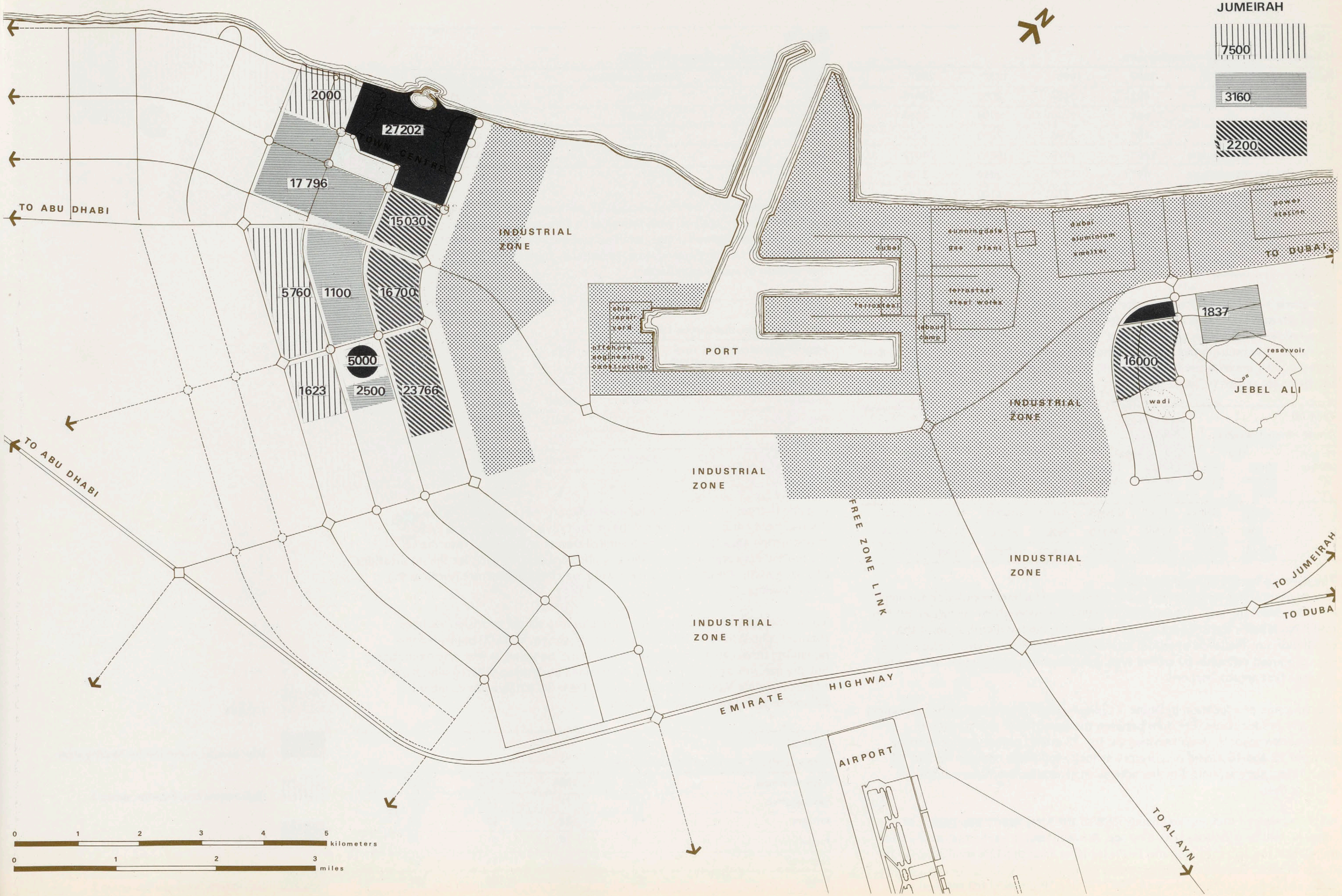
Industry

High density, mixed income housing areas

Low income housing areas, group 3

Middle income housing areas, group 2

High income housing areas, group 1



JUMEIRAH
7500
3160
2200
TO ABU DHABI
2000
27202
TOWN CENTRE
17 796
15030
5760
1100
16700
5000
1623
2500
23766
TO ABU DHABI
INDUSTRIAL ZONE
ship repair yard
offshore engineering construction
PORT
dubal
ferrostaal
sunningdale gas plant
ferrostaal steel works
labour camp
dubai aluminium smelter
power station
TO DUBAI
1837
reservoir
16000
wadi
JEBEL ALI
INDUSTRIAL ZONE
INDUSTRIAL ZONE
FREE ZONE LINK
INDUSTRIAL ZONE
INDUSTRIAL ZONE
TO JUMEIRAH
TO DUBAI
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
0 1 2 3 miles

Table 17

Housing demand schedule — dwelling units

House type		1981	1985	1997	2007
A	Large villa	403	1497	5066	22079
B	Villa	684	1760	3799	8203
C	Family house	480	2096	2896	5200
D	Worker family house	1660	1528	15643	26012
E	Worker shared house	467	1300	2640	3100
F	Worker shared dormitory	150	570	1100	1531
G	High cost apartment	2824	15416	19284	23026
H	Low/medium cost apartment	9217	18418	34591	49246
Totals		**15885**	**42585**	**85019**	**138397**

The above eight house types were for presentation purpose aggregated into three broad groups based upon the overall density standards, and for each group, total resident population was estimated. We simply aggregated the population attributable to house types A, B & G into Group 1, house types B, C, D, E, G & H into group II, house types C, D, E, F & H into Group III The resulting population estimates are shown in Table 18.

Table 18

Overall housing demand

Housing Group	1981		1985		1996		2007	
	Single person pop.	Family pop.	Single person pop.	Family pop.	Single person pop.	Family pop.	Single person pop.	Family pop.
I	2126	9366	5200	21048	9113	51850	10199	85400
II	7106	17286	17146	36310	28284	74442	34150	116400
III	12449	19022	32875	47485	64550	119337	83908	199000

The demand for educational facilities
The major problem which arises in the prediction of school population for Jebel Ali stems from the lack of a satisfactory data base upon which assuption can be made. No reliable statistics are available regarding the age distribution of the population nor the levels of school attendance. Despite these circumstances we have produced estimates by school type, but they must at this stage be regarded as initial first approximations.

The structure of education in Dubai is typically both private and public schooling generally in four stages. Children between the ages of four and six attend kindergarten schools, those between six and 12 attend primary schools, those between 12 and 15 attend preparatory schools; and those between 15 and 19 attend secondary schools. Further education generally commences at the age of 18 or over.

We have assumed that approximately 25% of the total family population of Jebel Ali will be of school attending age. A lower level is implied when the total population is taken into account, but it is higher than the 15% level adopted for Dubai in total. Our assumption produces estimates of 12,000 school children in 1981, rising to 100,000 in the year 2007. (Table 19 presents the results).

Table 19

Family and school population 1981—2007

Date	Family Population	School Population
1981	46000	12000
1985	104800	26000
1996	245600	62000
2007	401000	100000

The distribution of the school population estimates between the stages of education was undertaken with reference to forecasts of the likely percentage of pupils falling within each stage. We have assumed throughout the Master Plan period that these percentages remain constant. Table 20 records the resulting distribution of school population.

Table 20

School population distribution 1981—2007

Stage of Education	% of Total School pop.	1981	1985	1996	2007
Kindergarten	12	1400	3100	7400	12000
Primary	55	6600	14300	34100	55000
Preparatory	20	2400	5200	12400	20000
Secondary	13	1600	3400	8100	13000
Total	**100**	**12000**	**26000**	**62000**	**100000**

Organic changes in the demand for each category will occur during the development period as the age profile of the pupils increases — the typical phenomenon associated with the ageing of new communities. Nevertheless the limited data available precludes any allowance being made for the implications of such growth. Clearly this position will have to be closely monitored as the town develops.

To translate the school population estimates into school provision we have assumed school sizes of 100 pupils for kindergarten, and 600 pupils for the remaining three categories. These though must be taken as first approximations, but the size will be more precisely determined at detailed urban design stage. Accordingly for Master Plan calculations, Table 21 outlines the number of schools required with in each category.

Table 21

First estimate of number of schools required

Type of school	1981	1985	1996	2007
Kindergarten	14	31	74	120
Primary	11	24	57	92
Preparatory	4	9	21	33
Secondary	3	6	14	22
Total	**32**	**70**	**166**	**267**

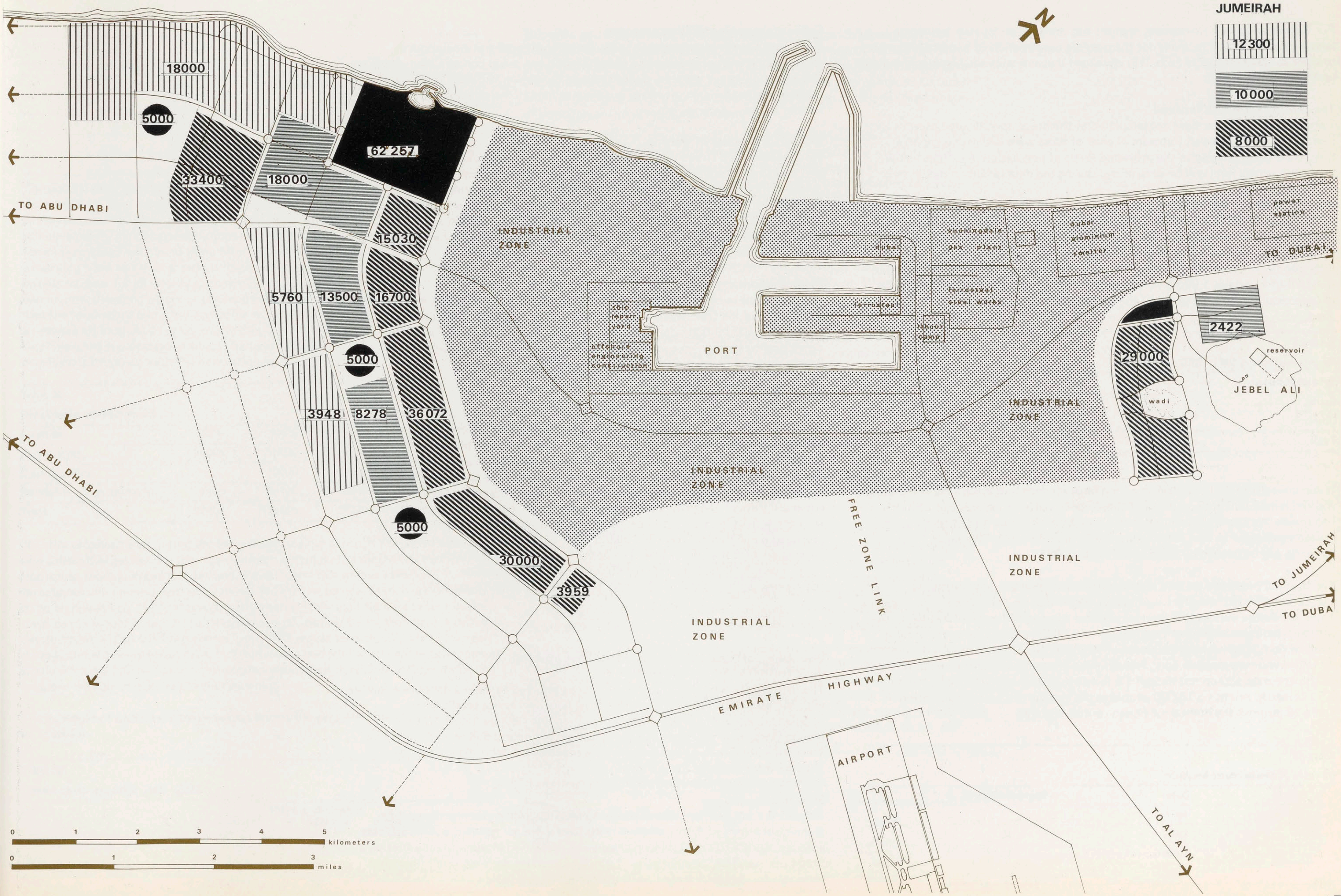
Industry

High density, mixed income housing areas

High income housing areas, group 1

Middle income housing areas, group 2

Low income housing areas, group 3


JUMEIRAH
12300
10000
8000
18000
5000
62 257
33400
18000
TO ABU DHABI
15030
5760
13500
16700
5000
3948
8278
36072
TO ABU DHABI
5000
30000
3959
INDUSTRIAL ZONE
PORT
INDUSTRIAL ZONE
INDUSTRIAL ZONE
FREE ZONE LINK
INDUSTRIAL ZONE
INDUSTRIAL ZONE
TO DUBAI
2422
29000
reservoir
JEBEL ALI
wadi
TO JUMEIRAH
TO DUBAI
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
0 1 2 3 miles

For further education no demand analysis was undertaken, but we feel that a land allocation should be made for the possible construction of two establishments to cater for 5000 students each. It is envisaged that one such establishment should be completed by 1985.

The demand for health facilities

Two levels of provision were contemplated at this stage, specifically hospitals and health centres. The overall numbers of each of these were determined upon a town wide basis, relating to the projected levels of population. Facilities below the health centre level will be determined during the detailed urban design stage.

Hospital provision was assessed with reference to the standards at present proposed by the Department of Health in Dubai, which have been adopted in full for Jebel Ali. The demand for acute bed space within hospitals was based upon the proposed provision of 3.5 beds per 1,000 resident population – in this case the total population estimated for Jebel Ali. For obstetric bed space we adopted the standard of 1 bed per 1,000 family population. Table 22 summarises the number of beds required for each phase of the Master Plan.

Table 22

Hospital bed spaces 1981–2007

Type of bed space	1981	1985	1996	2007
Acute	240	560	1220	1850
Obstetric	50	100	250	400
Total	**290**	**660**	**1470**	**2250**

It was considered that the ideal size for a large modern hospital would comprise approximately 600 beds, and would supply both acute bed spaces and obstetric bed spaces. We therefore propose that 1 hospital be built by 1981 and although exceeding demand at that date it should suffice up to 1985. Thereafter three hospitals will be needed by 1996, and four by 2007.

The hospital proposals are of a high standard, and generally the bed spaces exceed the demand, therefore we have envisaged that no polyclinics be provided in Jebel Ali. Below the hospital level we propose the establishment of health centres with approximate catchment populations of 10,000 people. Due to the varying levels of population density proposed in Jebel Ali, the physical catchment area envisaged will vary considerably. Nevertheless, we propose that the radius of these catchment areas should not exceed 1 kilometre, neither should they be less than 0.5 kilometre. Adopting 10,000 people as the average catchment population Table 23 outlines the number of health centres required.

Table 23

Schedule of health centre provision

Date	Number required
1981	7
1985	16
1996	35
2007	53

Other Community facilities proposed

Four areas have been examined briefly, incorporating general assumptions regarding the level of provision likely within the new town context. We include in this sector, places of worship, police stations, recreation and open space, and meeting places. All such provision is closely related to the physical form proposed for the town.

Mosques and places of worship

We propose that a Grand Central Mosque be located in the town centre complex and that large mosques be located in all district centres. Within the residential neighbourhood we propose a two tier structure with a local mosque to be provided for every 1500 – 2000 Moslem population, and a neighbourhood mosque for every 8000 – 12000 Moslem population. We further envisage places of worship being developed for the population of other denominations but at this stage it's too imprecise to make any specific recommendations.

Police Stations

Police stations must be located at accessible locations to the resident population and usually in the Gulf States they are provided for neighbourhood units of between 15 and 20,000 population. Accordingly we propose location in all district centres, the town centre (to act as the central police complex), and within the neighbourhoods on the basis of one station per 15000 people.

Recreation and local open space

Although the provision within this category will be examined in more detail during the local planning studies, we have briefly outlined the general rules within which such studies will be undertaken. Public open space and playing fields should be planned for at a standard of 1 hectare per 2,000 population within the residential neighbourhood, but this should be in addition to any major open space provision designed to serve the town as a whole. Indoor recreation facilities, as envisaged through the provision of sports halls should be located in accordance with the activity core structure proposed in the Master Plan. General locations proposed are within the local and district centres, either as individual units, or in association with the school sites. The demand for cinemas was estimated upon the basis of one, 1,000 seat cinema for 80,000 – 90,000 population. Accordingly one cinema is proposed by 1981, 2 by 1985, 4 by 1996 and 6 by 2007.

Shopping, offices, commercial facilities and the distribution of service employment

The demand for service employment has been assumed to form a direct relationship with the total employment of the industrial base, and hence total support population. Accordingly the estimates for shopping floorspace and office requirements were produced using assumptions for population related standards. The distribution throughout the town was made based upon the established physical form designed for the town.

Shopping

Accepting a full development of shopping facilities within the town, a realistic planning standard of 1.1m^2 of gross retail floorspace per resident population was adopted. Such a standard is representative of these used in other Middle Eastern States, for new development areas. Table 24 illustrates the total retail floorspace estimates for Jebel Ali according to the projected population

Table 24

Total gross retail floorspace demand

Date	Total Retail Floorspace (m^2)
1981	74400
1985	176100
1996	383400
2007	582200

The general principles adopted for the distribution of shops and shopping centres with Jebel Ali were based upon the proposed functions for each activity core within the physical plan. In retailing terms the town centre is expected to be the principle centre for comparison shopping, but also to function as a district centre for its immediate catchment population. The district centres are assumed to be of varying sizes, but they should be designed to provide an adequate range of retail outlets to cater for all weekly shopping needs. Since access to the district centres will involve travelling by car or public transport for most people, it is important that the local shops be highly accessible within the residential neighbourhoods, and a network of local shops or centres within 0.25 to 0.5 kilometre radius of all dwelling units is proposed as a basic standard. Phasing of the development of retail provision is proposed with the population build up.

Table 25

Distribution of retail floorspace

Location	1981	1985	1996	2007
Town centre	80000	80000	140000	180000
District centres	–	40000	140000	200000
Residential neighbourhoods	2400	56100	102400	202200
Total	**82400**	**176100**	**382400**	**582200**

We have proposed that during the early phase, mainly through the construction of a substantial part of the town centre retail complex, the supply of retail floorspace should exceed the demand. Nevertheless this should even out throughout the development programme. No district centres as such are proposed to be completed by 1981, although a large part of the retail floorspace within the town centre would in fact be functioning as a district centre by that time. Further development within the town centre, post 1985 would be primarily for high order durable and specialist goods sales, but during this period district centre development would attract a substantial share of convenience goods purchases and the more frequent durable categories of retail spending.

The schedule of district centre provision during the post 1981 period is outlined in Table 26.

Table 26

District centre provision 1985–2007

Date	Number of Centres		
	At 40,000m^2	At 10,000m^2	At 60,000m^2
1985	1	–	–
1996	3	2	–
2007	3	2	1

Basically we propose three sizes for the district centres; those serving neighbourhoods of approximately 70,000 people to contain 40,000 m^2 of gross retail floorspace, the two district centres east of the industrial area serving Jumayrah and the area of Jebel Ali satellite station each to comprise 10,000 m^2, and one centre to serve approximately 100,000 people during the final phase of development to comprise 60,000 m^2.

The retail floorspace proposed within the residential neighbourhoods will comprise small local centres or individual shops serving approximately 1,000 – 1,500 people located within 0.25 kilometres of the retail outlet, and large local centres comprising 1400 m^2 – 2000 m^2 of gross retail floorspace designed to serve approximately a catchment of 10,000 population. No definite numbers of locations for these local centres have been outlined in this Appendix and this exercise awaits more detailed local planning work.

The employment estimates for the retail sector were based upon an overall standard of one employee for every 20 m^2 of gross retail floorspace. Accordingly we have estimated employment levels of 4,100 in 1981, in 1985, 19,000 in 1996 and 29,100 in 2007.

Offices

The demand for offices was assessed within the context of overall employment estimates. Two main categories of employment were considered – Government services and non-Government office employment. The latter category was subdivided into local orientated office activities, and that associated with national or international enterprise.

Government Services

Within the Government sector of service employment we have included all departments of Government administration, education and medical services. A large part of such employment comprises non-office based occupations, for instance teachers, doctors, nursing staff etc., and accordingly estimates were made for both components.

We have assumed a lagged relationship between Government service employment and population growth, and that only by 2007 will the typical levels associated with Middle Eastern States be achieved. Accordingly we have adopted the assumptions that in 1981 20% of total service employment will comprise Government services. This percentage is predicted to rise to 30% in 1985, to 32.5% by 1996 and to 35% at 2007. Estimated levels of Government employment are thus 2,600 in 1981, 9,900 in 1985, 24,700 in 1996 and 41,800 in 2007.

To estimate the office component relating to the above employment estimates we have assumed that throughout the period typical ratios of Government office employment apply – specifically for every office job, three non-office jobs exist. Accordingly at every date we have estimated 25% of the total Government employment will be office based. Levels of office floorspace resulting from these employment estimates were calculated by applying a standard of 15 m^2 per employee. Table 27 illustrates the resulting predictions.

Table 27

Government office, employment and floorspace requirements

Date	Employment	Office Floorspace m^2
1981	600	9000
1985	2500	37500
1996	6000	90000
2007	10500	157500

Private commercial office

The locally oriented office based activity represented as banking, insurance finance, real estate, legal services etc., has been assumed to be directly proportional to the total employment of Jebel Ali. A level of approximately 5% of the total labour force (including construction employment) was considered realistic. Levels of office based employment for national and international companies at this stage must be purely speculative, and we have assumed a maximum level of 10,000 employment by 2007. Total private office employment of 3,400 in 1981, 8,000 in 1985, 15,000 in 1996 and 22,500 in 2007 were estimated. Applying an overall floorspace standard of 15 m^2 per employee, total private office floorspace was estimated (Table 28.)

Table 28

Private office employment and floorspace estimate

Date	Employment	Floorspace m^2
1981	3400	51000
1985	8000	120000
1996	15000	225000
2007	22000	330000

Distribution of office floorspace

The distribution of office floorspace throughout Jebel Ali was based upon the physical form of the town, with a strong central business district consisting approximately 60% of the total office demand by 2007. The remaining office floorspace was distributed between district centres and the residential neighbourhoods in the ratio of 2 : 1. Phasing was undertaken according to two principles;

(i) the proposed schedule of district centre development;

(ii) to provide levels of floorspace of sufficient quantity in the town centre to ensure its domination at any early stage.

Table 29

The distribution of office floorspace

Location	1981	1985	1996	2007
Town centre	60000	132000	208500	285000
District centre	–	25500	76500	135000
Residential neighbourhoods	–	–	30000	67500
Total	**60000**	**157500**	**315000**	**487500**

Wholesaling

We envisage the wholesaling facilities to serve the town being located primarily within the industrial area. No attempt was made to detail such provision, but we have assumed employment within this sector to equal approximately 20 – 25% of that predicted in retailing.

Hotels

No demand analysis was undertaken, but we have accepted that there will be considerable scope for the development of hotels in Jebel Ali. The present shortage of such accommodation in Dubai will increase. It is therefore essential to satisfy the demand for hotel accommodation generated by the commercial nature of Jebel Ali internally. We have therefore envisaged up to four hotels, each with 300 – 500 rooms, in the town – of these one should be in operation by 1981.

Other Service Employment

Arbitrary estimates were made for the private transport and communication sector of the economy – such an estimate covers taxi drivers, private haulage companies, motor repair establishments etc. The location of these activities we have assumed to be divided between the town centre, the district centres and the industrial area, in nearly equal proportions.

The distribution of service employment

Combining the estimates made with the prepared physical distribution outlined in the previous section, we have been able to make global estimates of the distribution of service employment throughout the town at the specified dates in the development programme. Table 30 summarises the resulting distribution.

Table 30

Distribution of service employment – 1981, 1985, 1996, 2007

Category	1981				1985				1996				2007			
	Town centre	District centres	Residential neighbourhoods	Industrial areas	Town centre	District centres	Residential neighbourhoods	Industrial areas	Town centre	District centres	Residential neighbourhoods	Industrial areas	Town centre	District centres	Residential neighbourhoods	Industrial areas
Retail	4000	–	100	–	4000	2000	2800	–	7000	7000	5000	–	9000	10000	10100	–
Wholesale	–	–	–	900	–	–	–	1700	–	–	–	4400	–	–	–	6800
Private office	3400	–	–	–	6800	1200	–	–	9900	3600	1500	–	12500	6000	3500	–
Government office	600	–	–	–	2000	500	–	–	4000	1500	500	–	6500	3000	1000	–
Other govt. employ.	300	–	1300	400	600	2100	4100	600	900	6300	10500	1000	2000	7500	18300	3500
Transport & communic.	500	–	–	500	600	800	–	600	2100	2300	–	2100	3000	4000	–	3000
Other	200	–	800	–	800	400	1400	–	1000	1200	4200	–	1000	2000	6800	–
Total	**9000**	**–**	**2200**	**1800**	**14800**	**7000**	**8300**	**2900**	**24900**	**21900**	**21700**	**7500**	**34000**	**32500**	**39700**	**13300**
		13000				33000				76000				119500		

Appendix C
Socio-economic groups and population distribution

Table 1 shows the total population for each phase broken down into socio-economic groups. Table 2 sets out a range of residential types and land use densities. Tables 3,4,5, and 6 divide the socio-economic groups into appropriate residential types, and show their distribution within the study at each phase of the town's development.

Table 1

Population: Socio Economic groups

	Dubai/other Arab		American/European		Other Immigrant		Totals
	Single	Family	Single	Family	Single	Family	
1981							
Group1	1161	5804	639	3581	326	271	**11782**
Group 2	1652	8260	241	4682	5213	4344	**24392**
Group 3	1652	8259	46	139	10751	10624	**31471**
1985							
Group 1	2797	13983	1568	6369	835	696	**24248**
Group 2	4027	20137	591	5733	12528	10440	**53456**
Group 3	4363	21815	114	341	28398	25329	**80360**
1997							
Group 1	4892	36688	2618	13445	1603	1717	**60963**
Group 2	5798	43482	848	7776	21638	23184	**102726**
Group 3	7428	55712	221	996	56901	62629	**183887**
2007							
Group 1	5197	60627	2902	21984	2100	2828	**95638**
Group 2	5966	69609	875	10082	27309	36762	**150603**
Group 3	8084	94310	199	1392	75625	103465	**283075**

Table 2

Residential types and densities

Type	Description	Net residential density: Dwellings per hectare	Net residential density: Persons per hectare	Gross residential density Person Per hectare	Occupants per dwelling
A	Large villa	6	36	**34**	6
B	Villa	11	55	**50**	5
C	Family house	21	105	**88**	5
D	Workers family house	30	180	**128**	6
E	Workers shared house	15	150	**114**	10
F	Workers shared dormitory	15	300	**228**	20
GF	High income family flat	160	640	**316**	4
GS	High income single flat	160	160	**79**	1
HF	Medium/low income family flat	140	560	**295**	4
HS	Medium/low income single flat	140	140	**74**	1

Table 3

Population distribution — 1981

Economic group	Type of resid.unit.	Population	Distribution: Town Centre	District Centre	Jumeirah	Jebel Ali	Districts
1	A	2416			900		1516
	B	1071			771		300
	GF	4504	4504				
	GS	3791	2665				1126
Totals		**11782**	**7169**		**1671**		**2942**
2	B	2350			1150		1200
	C	2260			160	600	1500
	D	3000					3000
	E	2213				1000	1213
	GF	6333	6333				
	GS	1241					1241
	HF	3340	3340				
	HS	3652	3652				
Totals		**24389**	**13325**		**1310**	**1600**	**8154**
3	C	139			139		
	D	6960			960	3000	3000
	E	2452				1452	1000
	F	3000				1000	2000
	HF	11923	2664				9259
	HS	6997				3000	3997
Totals		**31471**	**2664**		**1099**	**8452**	**19256**
Totals		**67642**	**24158**		**3280**	**10852**	**30352**

Table 4

Population distribution – 1985

Economic group	Type of residen. unit	Population	Distribution Town centre	District centre	Jumeirah	Jebel Ali	Districts
1	A	8983			3000		5983
	B	2900			2000		900
	GF	5200	5200				
	GS	9165	3165	1000	2500		2500
Totals		**26248**	**8365**	**1000**	**7500**		**9383**
2	B	5900			900	1000	4000
	C	10137	1000		260	837	8040
	D	8000					8000
	E	6000			2000		4000
	GF	7333	6333	500			500
	GS	3118					3118
	HF	4940	3340	1500			100
	HS	8028	4500				3528
Totals		**53456**	**15173**	**2000**	**3160**	**1837**	**31286**
3	C	341			200		141
	D	25000			2000	6000	17000
	E	7000				2000	5000
	F	11398				3000	8398
	HF	22144	4664	2000			15480
	HS	14477				5000	9477
Totals		**80360**	**4664**	**2000**	**2200**	**16000**	**55496**
Totals		**160064**	**28202**	**5000**	**12860**	**17837**	**96165**

Table 5

Population distribution – 1996

Economic group	Type of residen. unit	Population	Distribution Town centre	District centre	Jumeirah	Jebel Ali	Districts
1	A	30398			6690		23708
	B	7497			3497		4000
	GF	16665	16665				
	GS	6403	790	3500	2113		
Totals		**60963**	**17455**	**3500**	**12300**		**27708**
2	B	11500			5000	1000	5500
	C	13482	1760		5000	1422	5300
	D	19184					19184
	E	10000					10000
	GF	16276	11776	4500			
	GS	4646					4646
	HF	14000	14000				
	HS	13638	12540				1098
Totals		**102726**	**40076**	**4500**	**10000**	**2422**	**45728**
3	C	996					996
	D	74677			8000	10000	56677
	E	16401				4000	12401
	F	22000				10000	12000
	HF	42000	4726	7000			30274
	HS	27813				5000	22813
Totals		**183887**	**4726**	**7000**	**8000**	**29000**	**135161**
Totals		**347576**	**62257**	**15000**	**30300**	**31422**	**208597**

Table 6

Population distribution — 2007

Economic group	Type of residen. unit	Population	Distribution Town centre	District centre	Jumeirah	Jebel Ali	Districts
1	A	47455			12455		35000
	B	23019			11803		11216
	GF	16665	16665				
	GS	8499	790	4518	3191		
Totals		**95638**	**17455**	**4518**	**27449**		**46216**
2	B	18000			7500	1270	9230
	C	24609	1760		7500	2600	12749
	D	30762					30762
	E	12000					12000
	GF	22082	16600	5482		1000	4482
	GS	4840					4840
	HF	21000	21000				
	HS	17309	12540				4769
Totals		**150602**	**51900**	**5482**	**15000**	**4870**	**73350**
3	C	1392					1392
	D	125310			10000	10000	105310
	E	19000				5000	14000
	F	30625				13400	17225
	HF	72465	4726	10000			57739
	HS	34283				5000	29283
Totals		**283075**	**4726**	**10000**	**10000**	**33400**	**224949**
Totals		**529315**	**74081**	**20000**	**52449**	**38270**	**344515**

Table 7

Land use table of facilities ancillary to residential areas (excluding facilities within Town and District Centres)

Shopping		202200 sq.m.	20 ha.
Offices		67500 sq.m.	6 ha.
Public amenities:	Cinemas	6	3 ha.
	Sports halls	16	8 ha.
	Libraries	6	2 ha.
	Others		10 ha.
Colleges of further education		2	80 ha.
Schools:	Kindergarten	120	12 ha.
	Preparatory	92	110 ha.
	Primary	33	40 ha.
	Secondary	22	52 ha.
Hospitals		4	120 ha.
Health Centres		53	13 ha.
Public open space within neighbourhoods		1 ha. per 2000 people	200 ha.
Mosques and other religious buildings			25 ha.
Parking — off-street public			100 ha.
Services:	Electrical sub-stations		5 ha.
	Water distribution		5 ha.
	Fire stations	5	3 ha.
	Police	25	18 ha.
	Public transport		15 ha.
	Garages		20 ha.
		Total	**867 ha.**

Therefore, by the year 2007, a land use of 867 hectares will be required to support a population of 529,000, which is equivalent to 0.0016 ha. per person. This factor has been used in calculating the gross residential densities.

Appendix D
Transport

Introduction

Objectives in planning for transport
The interaction between the patterns of activity in any city and its facilities for transport implies the closest possible link between the planning of homes and work-places, centres for shopping and recreation and the planning of roads and car parks, buses, taxis and goods depots to serve them. In no small measure, the way of life of a people is determined by the ease with which they can move around within the city of their choice.

In determining the best structure for the city at Jebel Ali, the needs of transport have been borne continually in mind. The basically rectangular grid layout proposed is one which will enable a good balance of transport to be provided, an even spread of accessibility to be ensured, and a great deal of flexibility to be retained in the face of many unknowns and uncertainties in the future. The layout and structure which we have proposed can be readily adapted and modified to meet prevailing circumstances without destroying the principles and objectives upon which they have been based.

The time scale of the plan and the changes that could inevitably occur, particularly in the future levels of demand for travel, have required us to adopt this flexible approach. Nevertheless, we have sought to secure a number of objectives:

1 To provide a high degree of accessibility between all the different land-uses and places of activity making up the city: homes, work-places, schools, shops, health clinics etc.

2 To allow for freedom of choice between means of transport (even for those who will own their own cars)

3 To provide sufficient flexibility in the transport system to allow for the expected expansion of population and changes in their patterns of activity.

4 To develop a transport system which is both safe and attractive to those who use it, and yet minimises the impact on residents, works and the pedestrians' environment.

5 To keep the total amount of roadspace to be provided at each phase of the city's growth to a minimum, consistent with providing enough capacity to deal with the peak demands for travel without congestion arising in any part.

The need for flexibility
Some factors will have more critical effects on the design of the transport systems than others. For instance, for any given population density and urban form, the most important factors are the level of car ownership and average journey length. Both the relatively low overall density proposed for residential accommodation in the city and the low density of work places in the free trade and light industrial areas will tend to encourage high car ownership and relatively long trip between homes and work-places. Also the high activity rate of the population will tend to produce more trips than in comparable cities elsewhere. On the other hand, the concentration of jobs and the higher residential densities in the major commercial centres along the main activity "corridors" will facilitate the development of an efficient public transport system for these particular movements.

Despite the assumptions and predictions we have made, we recognise that future developments — particularly in transport technology — are inherently uncertain. Also the rate of influx of population to the area may be different and the preferences and predispositions of those people may not accord with those we have implied, in particular the levels of car ownership and sharing use of taxis etc. may vary. Thus we have recommended a flexible transport plan which is capable of accommodating the widest possible range of future demand; this is one of the strongest features of the hierarchical rectangular grid structure which we have proposed.

Assumptions underlying the transport proposals
Earlier we have described the estimates of population, employment and household structure appropriate at each phase of development. It is these estimates which form the basis of all calculations in this chapter. The population estimates largely determine the amount of travel; where people travel to and thus the routes used are determined principally by the relative location of homes, workplaces, schools, shops etc. The means of travel is determined by household structure, income (in terms of its influence on car ownership) and the density of homes and work-places.

A relatively high level of family households in socio-economic groups I and II and the relatively low density of industrial workers (40-20 workers per gross industrial area) influenced our assumption that car ownership and use would be high.

The balance of transport to be provided
The main highway network in its ultimate phase of development can be seen in figure 12 with the regional motorways and primary distributors forming the boundaries of the major areas of population and employment. Running between these, the secondary network of roads, less elaborate and less costly than the motorways, would connect to the numerous district distributors within each area providing for local movement and access to the district centres.

The 'spine' of public transport, represented possibly by a minitram system (see Appendix E), will join all these district centres to the city centre and to all other major concentrations of activity. This high capacity spine can then be complemented by local "feeder" bus services operating in each local area and supplemented by longer "cross-town" bus routes linking specific residential and employment areas. Such cross-town services might only operate at peak periods of the day, associated with journeys to and from work.

This basic framework of public transport can then be filled out with an appropriate number and range of licensed (but otherwise free-enterprise) operators of taxis, shared taxis, minibuses, company transport, jitneys, etc. who have been so successful in meeting the shifting patterns of demands in cities all over the world. This proposal is discussed further later on.

Finally, properly designed parking areas for cars and service vehicles have been allowed for within each of the district centres so that those areas are fully accessible for both people and goods. In view of the considerable space required for parking, this has been given special attention in the design of the town centre.

Estimates of travel demand

The method adopted

In order to estimate the travel demand likely to arise at any particular phase of the city's development, we make use of simple mathematical models. The models describe a number of distinct, sequential stages. First, they enable us to estimate the number of trips entering or leaving different parts of the study area over any given period of time. Secondly, they estimate the distribution of trips between the various areas of the city, and thirdly they determine the mode of travel use for each trip. Finally each journey can be allocated to its most appropriate route through the highway network. These stages are known as trip generation, trip distribution, model split and assignment, respectively. In this way, we can forecast for any configuration of highways what the traffic flows are likely to be in relation to the size of the population, its density and disposition and the prevailing level of car ownership. Adequate capacity can then be provided to meet the peak period demands. Similarly, the overall demand for public transport can be estimated and services planned accordingly.

Ownership of private cars and other vehicles

As one of the key variables, car ownership will affect the level of trip generation and choice of mode, whilst average trip length will affect the distribution of trips and their assignment to the highway stem. A number of techniques exist for predicting future levels of vehicle ownership but most of these rely on knowledge of future per capita income — estimates which are not available to us. The 1976) level of vehicle ownership in Dubai is about two-thirds of this total (i.e. 90 cars per 1,000 population, about 19,000 cars). Car ownership is currently increasing at about 15% per annum and, at this rate, the number of cars will have more than doubled by 1982. Such a high rate of growth is unlikely to continue indefinitely and experience in other countries suggests that the rate of growth will decline and car ownership approach a 'ceiling' (or saturation level). This saturation level will largely determine the future amount of travel in Jebel Ali. Knowing the existing level of car ownership, the current growth rate and the likely saturation level it is possible to estimate car ownership levels for any particular year, assuming income levels continue to rise.

In Europe and North America where car ownership and income levels are already high, the saturation level appears to be in the range of 1.4 to 1.8 cars per household. We have used these levels as a basis for our calculations.

The overall level for Jebel Ali reflects the high proportion of single person households likely to be found, particularly in socio-Economic Group III. Alternative high and low forecasts have been prepared, Table 2, and these forecasts can be applied to the high and low population forecasts to illustrate the wide range of ownership rates that may occur in the new city. These ownership levels will also be materially affected by government and development agency policies and the levels of ownership of the single person households may be susceptible to transport policy decisions too. We consider the middle range of ownership forecasts to be the most realistic. The high, middle and low forecasts are illustrated in the diagram which shows how car ownership levels may change over time from the current base level. It shows that saturation levels could occur at about the same time as the city reaches its target of 529,000 population.

The ownership levels indicated above are assumed to include government-owned cars and motor cycles. Separate calculations need to be made for other vehicles (light medium and heavy goods vehicles, buses and coaches etc.) which in 1976 formed about one third of the total number of vehicles registered in Dubai. Levels of commercial vehicle ownership, in particular, will be significantly influenced by the way in which the port and free trade areas develop. We have assumed that these "other" vehicles will ultimately form about 20% of total vehicle numbers. Thus, at saturation level, for a population of 529,000 we estimate there will be a total of 182,000 vehicles in the new city of which some 36,000 will be commercial vehicles and buses.

The estimated growth in vehicle numbers on which the demand for travel is based is set out in Table 3. The table shows that the number of vehicles increases at a faster rate than the change in population, reflecting the rapid increase in ownership levels. Over time the number of lorries and buses, as a proportion of total vehicles, falls as we expect.

Journeys to work by various modes of transport

The lack of comprehensive travel data for Dubai and Jebel Ali has caused us to develop a model for travel based on the journey to work. This approach provides estimates of the peak loading on the different transport systems — desirable as a design criteria — on the assumption that peaks of travel are associated with work-journeys.

First we have used the various employment estimates to determine the total number of work trips. Secondly we applied the car ownership levels summarised above to calculate the proportion of people going to work by car (allowing for some car sharing). Finally, by deducting from the total number of workers the numbers travelling by car, the remaining workers have been allocated to public transport and non-motorised modes (walk and bicycle).

At first, a high proportion of the non-car trips are likely to be made by non-motorised modes. However, as the city develops and becomes more dispersed, the proportion of these trips will fall rapidly and will tend to be restricted to trips within the local residential areas. The public transport trips will include trips by shared taxis and other free-enterprise modes. Table 4 shows the final estimates of the proportion of work trips by various modes for the city as a whole.

Table 2

Range of saturation car ownership levels for the new city

Socio-economic groups within the population	Average no. of cars per head: High growth	Medium growth	Low growth
I	0.50	0.40	0.35
II	0.40	0.35	0.30
III	0.30	0.20	0.10
Overall averages	0.36	0.28	0.20

In order to determine the total amount of motorised travel occurring in one peak hour, we have taken account of the numbers of employees starting work in the peak hour, their mode of travel (as above), the number of trips made for purposes other than work and the amount of commercial vehicle traffic. Traffic studies in Dubai suggest that the proportion of daily travel in the peak hour is significantly lower than in similar cities elsewhere. Consequently, we have assumed that only 40% of the journeys to work will occur in the peak hour and that, of the total peak hour person trips, 80% will be work trips. Table 5 shows the total journeys in the peak hour by motor vehicle. Because of the high level of industrial activity we have assumed that commercial vehicle trips will form 10% of all peak hour vehicle trips.

Estimates of road-space requirements
The distribution of the travel between the various origins and destinations is largely determined by how willing people are to travel long distances to work, shop etc., when other opportunities are closer to hand. This characteristic has been examined in various cities in Britain and the Middle East and, after allowing for differences in urban structure, it would appear that the rate of decline in desire to travel as journey time increases is reasonably consistent for a wide range of city sizes. From such studies we have established a relationship for the reluctance to travel long distances and use to predict both the patterns of journeys in the new city and the total amount of travel to be accommodated (in vehicle-kilometres).

Table 6 summarises the cumulative time likely to be spent in peak hour travel at each phase of the city's development. We have assumed that as the city increases in size the transport systems expand in such a way that average travel times remain roughly constant at 20 minutes for car trips and 25 minutes for public transport trips (including waiting time).

Table 7 shows vehicle-kilometrage and national forecasts of the length of the highway network required for each phase of the plan. The estimates of road space requirements are based on the adoption of (a) direct routeing for vehicle trips and (b) similar levels of services for traffic on all network links. The estimates result in a 75% utilization of capacity in the peak direction of travel. For the calculations, we have assumed an average occupancy for buses of 40 persons and we have expressed the number of buses and trucks in terms of passenger car equivalents (pcu) where one bus or truck is equivalent to two cars.

The conversion of total pcu-kilometres of "demand" for road-space into the overall lane-kilometres of "supply" depends upon both the design capacities of the highways concerned, and the configuration of the network proposed. The design capacities are given in Chapter 6, table 1 and the preferred network, based on a hierarchical system of road, is shown in figure 12. This preferred network formed the basis of the more detailed calculations which we now describe.

Table 3

Growth in numbers of vehicles in the new city

Date	Population	Number of vehicles: Cars & motorcycles	Other vehicles	Total	Average vehicle ownership level (vehicles/head)
1981	67,000	10,000	3,000	13,000	0.22
1985	170,000	33,000	9,000	42,000	0.26
1996	347,000	91,000	22,000	113,000	0.33
2007	529,000	145,000	36,000	182,000	0.35

Table 4

Proportion of work trips by mode of tansport

Year	Work trips by mode (% total)			Average vehicle occupancy	
	Car	Public transport	Walks & ride	Car & m/cycle	Bus
1981	30	55	15	1.5	40
1985	40	50	10	1.4	40
1996	50	40	10	1.3	40
2007	60	35	5	1.2	40

Table 5

Total vehicle trips in a typical peak hour

Year	Total vehicle trips in peak hour: Car and motorcycle	Public transport (vehicles)	Commercial vehicles (vehicles)	Total vehicle trips
1981	3,000	170	300	**3,500**
1985	11,000	410	1,200	**12,500**
1996	30,000	680	3,400	**34,000**
2007	62,600	910	7,100	**71,000**

Table 6

Peak hour trip lengths and travel demand (motorised modes only)

Year	Average trip lengths car mins	km	Public transport mins	km	Cumulative person-hours of travel in peak hour Car	Public transport	Total person hours
1981	20	10	25	6.25	1,300	2,800	**4,100**
1986	20	10	25	6.25	4,300	6,800	**11,100**
1996	20	10	25	6.25	11,300	11,300	**22,700**
2007	20	10	25	6.25	20,900	15,200	**36,100**


SCREEN LINE 2
SCREEN LINE 1
JUMEIRAH
11
1
B
2
TO ABU DHABI
3
A
TOWN CENTRE
4
F
INDUSTRIAL
ZONE
dubai
sunningdale
gas plant
dubai
aluminium
smelter
power
station
TO DUBAI
ferrostaal
steel works
ferrostaal
ship
repair
yard
offshore
engineering
construction
PORT
labour
camp
C
6
G
H
L
INDUSTRIAL
ZONE
12
reservoir
JEBEL ALI
wadi
5
TO ABU DHABI
I
INDUSTRIAL
ZONE
K
FREE ZONE LINK
D
8
J
INDUSTRIAL
ZONE
7
TO JUMEIRAH
TO DUBAI
INDUSTRIAL
ZONE
E
9
10
EMIRATE HIGHWAY
AIRPORT
M
TO AL AYN
0 1 2 3 4 5 kilometers
0 1 2 3 miles

Estimates of travel demand

Estimates of inter-zonal travel

To test the adequacy of the road network at the final phase of development (year 2007) detailed estimates of the distribution of travel demand were made. For this purpose the new city was divided into zones, figure 32. Zones numbered from 1 to 12 correspond to the residential districts. Zone A is the town centre; zones B, C, D and E are the district centres and zones F to M include the port, the airport and the other main industrial areas.

The method of estimating the distribution of trips between these zones was as follows. First we used the employment estimates from Appendix C and the population distributions from Chapter 5 to calculate the number of workers, and hence work trips in each zone. We then applied our car ownership levels to calculate the number of work trips by each mode. Different car ownership levels were used according to the socio-economic status of the workers.

The next stage was to eliminate those trips which would start and finish entirely within one zone since such trips do not contribute significantly to travel on the main highway network. Usually a very high proportion of such trips will be made by bicycle or on foot. However, since we have used relatively large zones some of these trips are made by car or by public transport. We also adopted the principle that all jobs located within the residential districts were filled by workers who lived locally.

The overall modal split figures used for the journey to work correspond to those set out in table 4. For each individual zone, the split between modes varies according to the level of car ownership and proximity to the public transport system. We then converted these work person-trips to peak hour vehicle trips using the method we have described earlier. Table 8 shows the resultant distribution of peak hour trips between the various zones of the city. These inter-zonal vehicle trips represent about 93% of all peak hour motorised trips. The trips shown include buses and commercial vehicles.

The distribution of trips shown in table 8 were obtained using a mathematical model of the form

$T_{ij} = r_i s_j P_i A_j F(t_{ij})$

Where:

P_i = trips produced in zone i
A_j = trips attracted to zone j
T_{ij} = trips from i to j
t_{ij} = travel time between i and j
r_i, s_j = constants; to ensure that total numbers of trips produced and attracted are all accounted for
$F(t_{ij})$ = a measure of the deterrence to travel between i and j.

The form of the function F (tij) used was based on our studies of other cities elsewhere. We tested a number of functions, some based on travel time, some on travel distance, and we adopted the final form.

$F(t_{ij}) = e^{-0.086\, t_{ij}}$ as providing the best representation of "travel deterrence" for Jebel Ali.

The travel time between each origin and destination was found by measuring the distance along the roads between the centre of each origin and destination zone and converting distance to time spent travelling using the speeds set out in table 1, Chapter 6. The diagram shows the frequency distribution of inter-zonal trips produced by our model. The mean trip length of kms reflects the weighted average of the car and bus trip lengths shown in table 6.

Assignment of trips to the road network

To check the sufficiency of the roads provided in the Master Plan, figure 12, we assigned the peakhour vehicle trips to a spider network. The spider network is a simplified network where roads can be represented by a series of direct connections between zone centres. It is particularly useful for comparing the amount of traffic crossing a screen line with the corresponding road capacity. The diagram shows that the total peak hour traffic crossing screen line 1 on figure 32 is about 37,000 passenger car units per hour. The majority of this flow is from the new city towards the industrial area. The capacity of the roads shown as crossing the screen line on the Master Plan is between 30,000 and 35,000 passenger car units per hour in each direction. In addition to the major highways there are a number of local streets which pan under the primary roads, figure 27, which have a combined directional capacity of more than 8,000 pcu/hr. Thus the total directional road capacity across screen line 1 exceeds the peak hour flow by at least 15%

Similar calculations were carried out for other screen lines — notably screen line 2 around the city centre. The total peak hour flow across this screen line is about 23,000 passenger car units per hour split 2 : 3 by direction. The total two-way capacity of primary and secondary roads across this cordon is about 32,000 passenger car units per hour and provides sufficient spare capacity.

Public transport trips

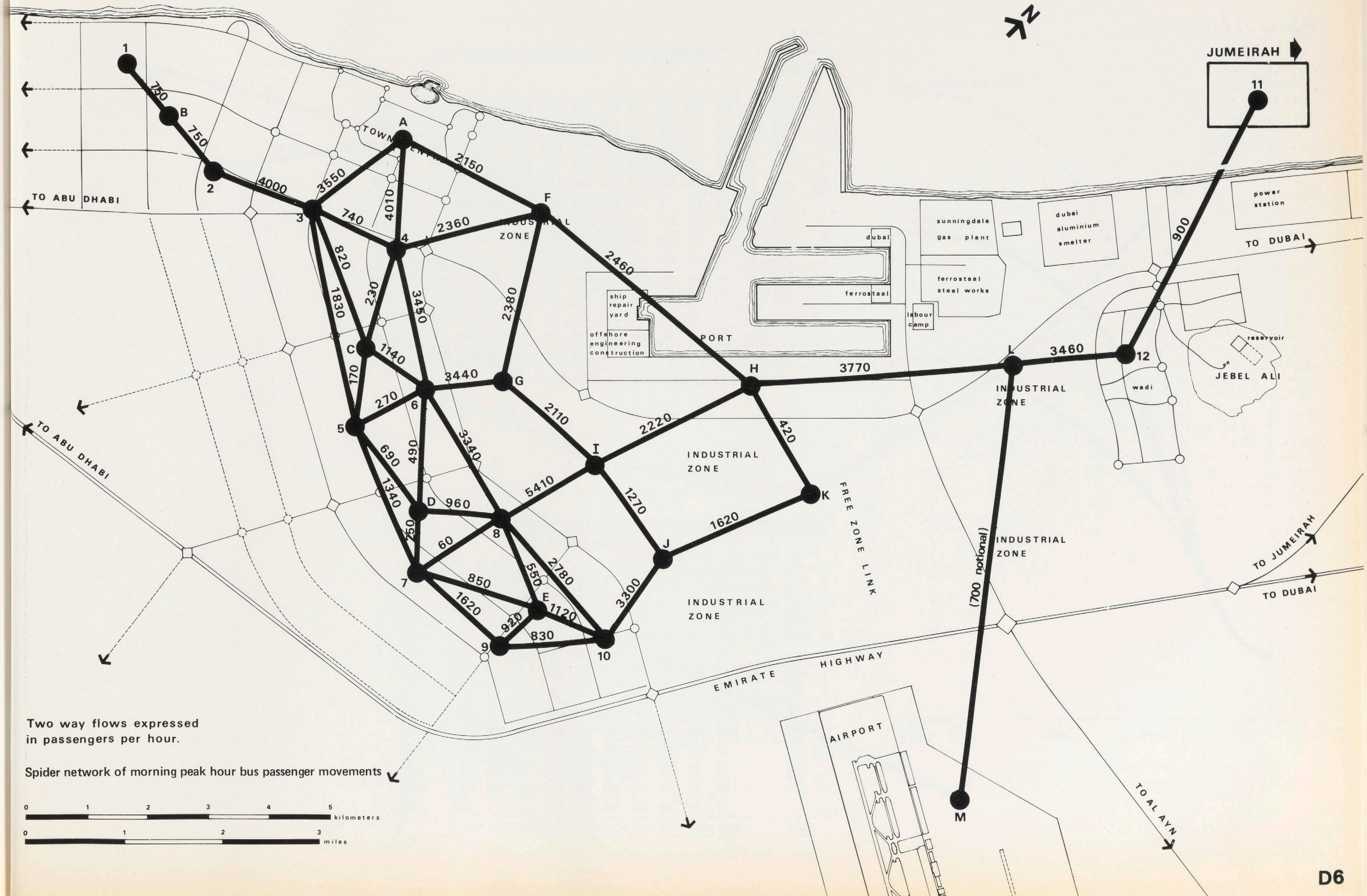
A similar analysis to that described above was carried out separately for public transport trips. Table 9 shows the distribution of inter-zonal trips by public transport modes. The majority of the public transport trips are to and from the city centre. Because of its compact form and good public transport accessibility we have assumed that half of the peak hour trips to the city centre are made by public transport. A high proportion of trips to the immediately adjacent industrial areas are also made by public transport.

The diagram shows the assignment of these trips to a spider network. The bus spider network represents the simplified bus routeing system, figure 18. The combined peak hour passenger flow for the three main bus corridors ranges from 7,000 to 9,000 passengers per hour. Between Jebel Ali and the new city flows are also high, ranging from 3,000 to 4,000 passengers per hour.

Table 7

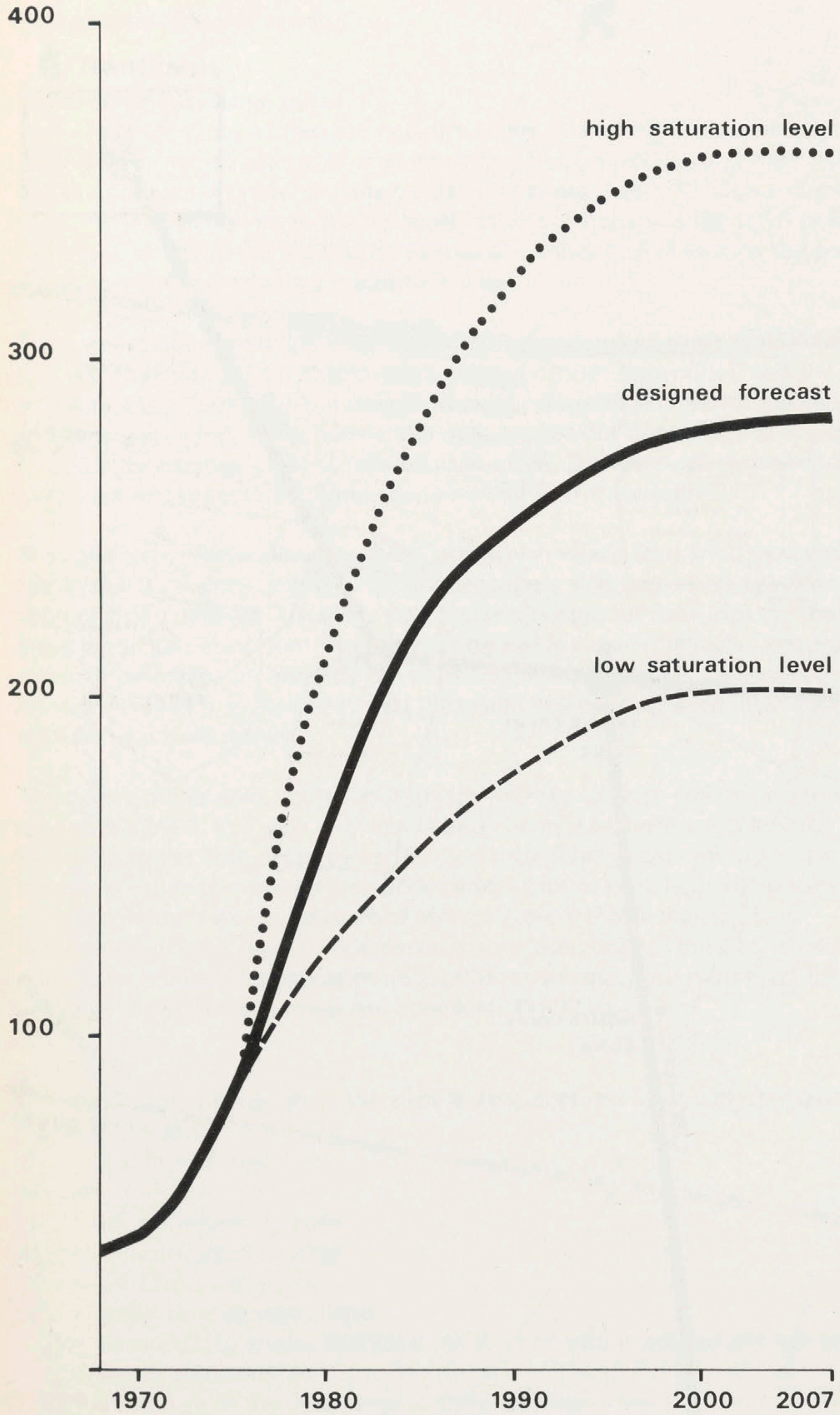
Total vehicle kilometres of travel and road-space requirements for Jebel Ali

Year	Vehicle-km of travel in peak hour: All vehicles (pcu-kms)	Buses (bus-kms)	Total road-space requirements (lane-km)
1981	42,000	1,000	**50**
1985	154,000	2,500	**160**
1996	347,000	4,300	**350**
2007	853,000	5,700	**790**



Two way flows expressed
in passengers per hour.

Spider network of morning peak hour bus passenger movements



Car ownership estimates

Table 8

Distribution of vehicle trips between origins and destinations (morning peak hour).

	Destination													
	A	B	C	D	E	F	G	H	I	J	K	L	M	
1	1280	1030	170	140	130	910	530	570	480	390	770	460	340	**7230**
2	1160	320	80	60	50	360	220	230	200	150	300	180	130	**3450**
3	1700	300	350	190	150	960	770	510	560	350	680	400	280	**7230**
4	450	80	240	210	110	400	400	330	420	250	420	250	160	**3500**
5	470	80	250	220	120	410	410	340	430	250	430	250	160	**3820**
6	510	80	250	200	110	450	480	360	470	260	450	260	170	**4040**
7	190	40	60	200	120	170	240	200	260	150	340	160	100	**2230**
8	270	50	80	200	210	240	340	200	470	260	540	220	150	**3250**
9	210	40	60	100	380	190	250	290	430	470	540	230	160	**3350**
10	220	40	60	100	360	210	260	310	470	700	700	270	200	**3890**
11	530	120	90	110	140	520	510	950	560	540	1390	1610	750	**7810**
12	230	50	40	50	60	240	230	470	250	280	830	1050	380	**4150**
A	–	610	330	260	250	2410	1510	1210	1070	840	1590	760	630	**11480**
	7170	**2820**	**2040**	**2640**	**2210**	**7420**	**6130**	**6050**	**6000**	**4840**	**9000**	**6100**	**3620**	

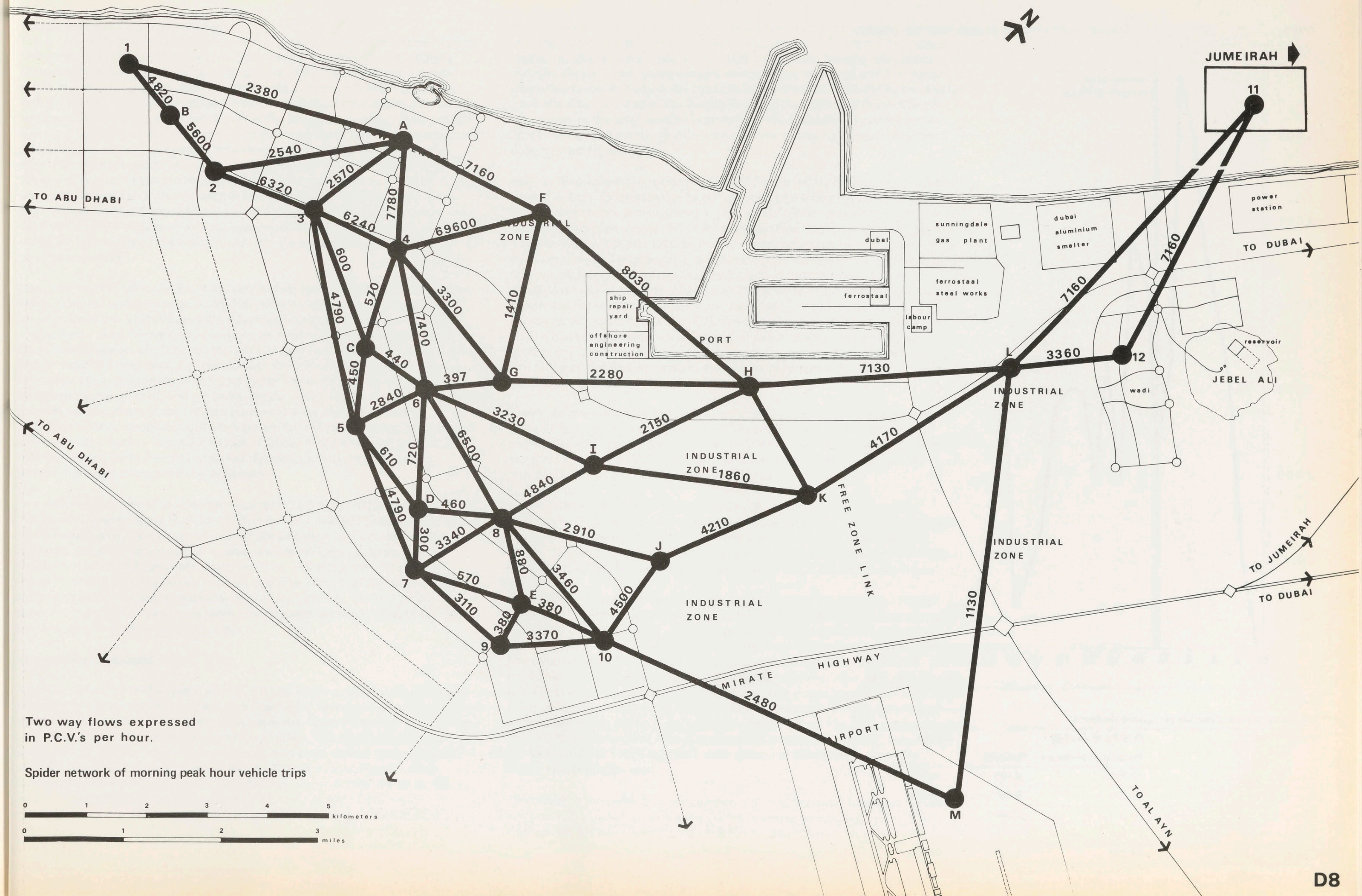
Note: All values have been rounded to nearest 10 trips.

Table 9

Distribution of bus passengers between origins and destinations.

	DESTINATION													
	A	B	C	D	E	F	G	H	I	J	K	L	M	
1	250		30	20	20	150	70	50	50	50	40	20	0	**730**
2	1150		130	90	70	600	330	220	210	190	160	100	0	**3750**
3	650		110	50	40	310	220	100	110	80	70	40	0	**1780**
4	1420		160	80	60	650	410	160	200	150	110	70	0	**3480**
5	140		60	50	20	110	90	50	70	50	40	20	0	**710**
6	820		320	240	170	600	510	280	400	260	190	120	0	**3910**
7	40		10	30	20	30	40	20	30	20	20	10	0	**270**
8	480		110	270	240	350	450	250	380	220	250	110	0	**3110**
9	400		100	150	480	310	360	280	440	550	280	120	0	**3460**
10	420		90	140	440	330	370	290	460	810	350	150	0	**3850**
11	130		20	20	20	110	100	120	80	80	100	120	0	**890**
12	330		50	50	60	280	250	340	190	250	320	440	0	**2540**
A	–		70	50	50	550	300	160	150	110	110	60	0	**1660**
	6230		**1240**	**1240**	**1620**	**4380**	**3610**	**2330**	**2760**	**2850**	**2040**	**1380**	**0**	

Note: All values have been rounded to the nearest ten trips



Two way flows expressed in P.C.V.'s per hour.

Spider network of morning peak hour vehicle trips

0 1 2 3 4 5 kilometers

0 1 2 3 miles

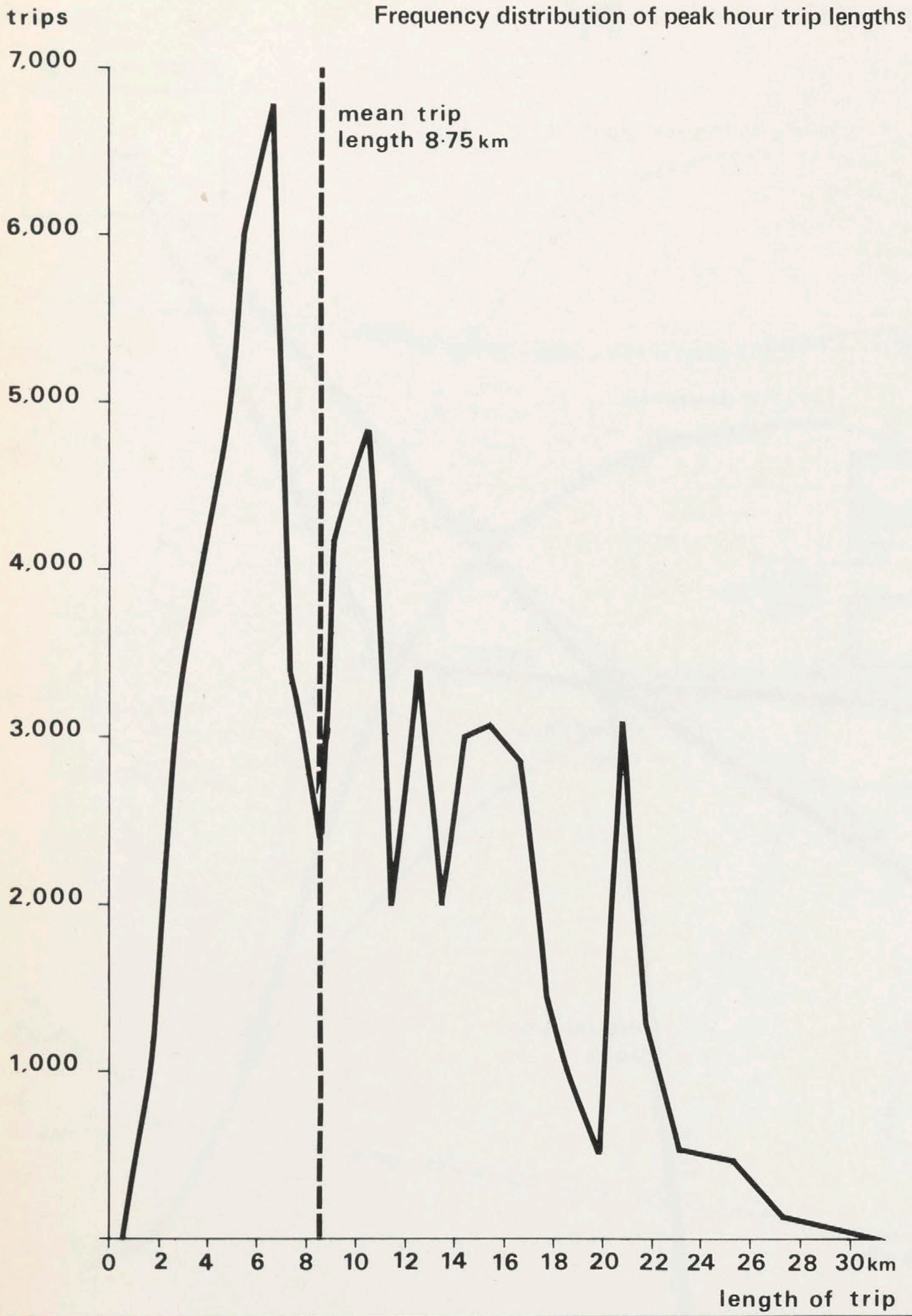


Table 10

Non-residential off street car parking requirements

Zone	Purpose of Journey		Total
	Personal and business	Shopping	
Town Centre	10,300	8,100	18,400
District Centres	4,800	10,800	15,600
Jumeirah	600	1,200	1,800
Neighbourhood	17,500	4,100	21,600
Total	**33,200**	**24,200**	**57,400**

Appendix E
Technical description of mini tram system

Scope for a mini tram in Jebel Ali

The city is likely to be of a sufficient size and population to warrant some form of high-capacity public transport system. Such a system would reduce or at least postpone the need for some of the high capacity roads thus achieving a direct saving on capital costs. The potential advantages of such a transport system are considerable but they will be realised only if the quality of the service offered is sufficient to satisfy the needs and desires of the populace. A system must provide a fast and frequent service; it must be available at all hours; it must have easy and closely-spaced access points and it must impose the minimum of detrimental effects on the surrounding area and it must harmonise with the remainder of the city structure. These criteria are met to various degrees by the different transport systems currently operated in cities throughout the world but, if a high proportion of the population is to make effective use of public transport in Jebel Ali, its level of performance achieved must be an improvement on what has so far been offered elsewhere. In addition, the system should be modern in concept and design.

Desirable levels of performance in the public transport system can be achieved by overcoming the restraints imposed by individual drivers controlling individual vehicles. Once the vehicles have been automated they can be reduced in size and consequently much higher frequencies can be obtained. Though a segregated track is necessary on which to run the vehicles their reduced size keeps track and station costs to a minimum; and even though the civil engineering work implied represents a high proportion of the total system costs, this can be off-set by the attendant savings on roads and car parks. Hence overall capital investment may be reduced and, by virtue of the reduced labour force required to operate an automatic system, compared with a bus system for example, running costs are low even with a twenty four hour service. If labour is likely to be in short supply over the coming years, keeping down the numbers of workers employed in running transport services may be important.

One system which would provide the required facilities in an advanced form is "Minitram"* and its application to the city has been studied to obtain some idea of the overall advantages obtained from its use as a basic high capacity public transport system. It would not, of course, obviate the need for buses and taxi services but would instead complement them (as was explained in the report). Figure 33 shows how a Minitram network might be fitted into the city structure and how it could evolve and expand with the city's growth. The rest of this appendix is devoted to describing some more detailed technical considerations of building up a basic network of this kind.

The system proposed

A precise definition of the final layout of the city is not possible at this stage and hence the Minitram system proposed here is an initial tentative illustration of one solution to match the city's transport requirements. Nevertheless it is sufficiently detailed to show how it might be applied in practice. The broad layout being considered for the city enables transport corridors to be defined with relatively short access routes linking to housing and working areas but, though overall residential densities in the corridors are fairly low, flows of peak traffic as high as 20,000 persons per hour may be generated. Corridor traffic of this order certainly warrants consideration of public transport carrying up to 50% of the peak commuter flow and such a requirement is well within the ability of Minitram.

The proposed route layout shown in figure 33 assumes a modal split of 50% for the medium and longer distance commuting journeys by Minitram. Two spinal routes run parallel along most of the length of the main housing and Service Industry area and two routes connect with the basic industrial and Port areas. One of these routes through the Industrial Area could be extended to the Airport while the other could serve the Aluminium Smelting Plant and Power Station with a spur to the small housing area close by the telecommunications centre. Scope would exist for the eventual continuation of the main route along the coast to connect with Dubai.

Further development of housing areas could be served by extensions of these main "spine" routes. Extensions can be constructed, in the first instance, as single track with alternate one-way working but where further growth or extensions are envisaged provision should be left for bringing these tracks up to "dual" standard. The ease with which additions to the Minitram system can be made is one of its main advantages. The phasing of the development (particularly the construction of a second track) depends upon capacity and, at peak periods, capacity is dependent in some respects on the handling capacity of the stations. On the more heavily loaded routes double platform, so called "D-loop" stations, will be necessary. For those routes initially using single track working where single on-line platforms are used space for station expansion should be provided if there is any likelihood of increased passenger flows in the future. The small size of the on-line stations ensures that the space required for future expansion is small.

Trains are envisaged for peak period operations, comprising three cars each of 42 passengers as a maximum capacity. This provides a practical capacity for planning purposes of 84 passengers per train with most people seated and a few standing. Flows of 10,000 passengers per hour in one direction would then require 119 trains per hour or on average a half minute service.

Lower levels of demand could be served by proportionately longer service intervals but in practice many of the lower loaded sections will still have a high frequency as they must deal with the return of empty trains especially in a "tidal" flow situation. Even when frequency is matched to peak demand a five minute service can be operated for flows of only 1,000 passengers per hour.

If the section of network subject to lower flows is part of a separate "feeder" route with pedestrian interchange onto more highly loaded routes then trains can be broken down into single vehicles maintaining higher service frequencies of less than two minutes at 1,000 passengers per hour and in proportion such that a five minutes service still implies high vehicle occupancy and a reasonably economic operation down to only 300-400 passengers per hour. It is at this lower end of passenger demand that single track working is appropriate with vehicles or trains passing at double-sided station platforms. However, though frequencies can be provided where traffic permits within a range of from one half to five minutes, say, due to the absence of drivers employed to operate the vehicles, frequencies can be retained at a high level with little economic disadvantage even when traffic falls from the peak.

**Minitram* is the name given to a system of public transport based upon small electrically-propelled automatically controlled vehicles running on their own track which has been developed by Hawker Siddeley Dynamics (UK) Limited.

Traffic in the basic industry area may fall to a fairly low level during midday but in the main housing and service industry areas it is unlikely to fall below a quarter or a fifth of peak figures. Since the peak flows involve mixed seated and standing passengers – roughly half and half – midday traffic at 25% of the peak still involves at least 50% of the peak vehicles if all midday passengers are to be seated. Hence even with low midday traffic it is not expected that service intervals will be more than twice those during the peak. For these reasons, service intervals will be down to half a minute in the peak on heavy traffic routes and can be as good as two minutes over the rest of the system and for most of the daylight hours with a possible reduction of these intervals down to one minute or lower if the extra cost was thought justifiable. Decisions about these more detailed aspects of the system must await a study of feasibility done in far greater depth than has been possible here.

Optimum service speed is dependent primarily on station spacing. Closely spaced stations limit achievable maximum speeds and hence limit service speeds. With a station spacing of half a kilometre, a service speed of 30 kilometres per hour can be achieved while at one kilometre spacing the service speed can exceed 40 kilometres per hour, assuming in both cases that all vehicles (or trains) stop at all stations. On the heavy traffic routes, where D-loop stations are used, mixed stopping and "limited stop" express services can operate with maximum running speeds up to 55 kilometres per hour. It may be desirable to build D-loop stations on certain sections of route, even where the traffic requirement does not warrant it initially, in order to take advantage of this mixed operating capability. Once again, only a detailed design study will reveal the instances where this is desirable.

The automatic control on the minitram system will permit a range of complex operations but care must be taken to ensure that any resulting complex mix of services does not confuse the passengers. Hence although claims for a large range of varying performances have been made by designers of the various automatic transport systems that have been developed, these claims are of little significance when planning an actual network for a real city. On the contrary, simplicity is probably the keynote. Suffice it to say, however, that the high speed and frequency of service, the small minimum track radius of curvature and steep incline capabilities of minitram and its high capacity coupled with a small operating corridor provide, by themselves, a considerable advance over more traditional public transport systems.

Despite the incentive of a fast, modern minitram network, 50% of the long and medium distance commuters will probably travel by car and provision is available for them on the primary road network. In each of the separate main housing areas local bus services can operate for short distance commuting and act as "feeder" services to the minitram stations. Hence the total transport facilities will comprise the three levels, car, bus and transit, similar to that which exists in many large cities but the mix will differ from most with a larger proportion of transit commuters than is general for cities of this size. With freedom from congestion, the overall social economy will be greater than that so far achieved in older cities.

The flexibility of transport planning which minitram permits coupled with a planned evolution of the system layout will provide a facility which is ideally adapted to cope with the initial rapid growth of the city. In the more detailed considerations of the final size and shape of the building programme extending over the initial fifteen year period care must be taken to ensure a continuing expansion of transport facilities designed to match the expanding demands. This is particularly important over the first few years of city growth to prevent the onset of congestion.

Some technical details of the system

Scale of system
A range of different vehicles sizes and interiors can be specified. The one illustrated is a small one, only some 6.6. metres long. It can seat twelve people with luggage and bicycles etc. or with thirty people standing. A single track is only about 2 metres wide and it can be supported on slender columns every twenty metres or so, keeping the vehicles clear of the ground below. Foundations can be relatively simple and the light design permits relocation of the installation to meet a later need. The system can also be installed segregated at grade, or underground.

Operations
One can start with the minimum fleet of vehicles necessary to handle the initial peak traffic. Starting and stopping, spacing, collision avoidance and routeing are all automatic. Maintenance can be largely effected by motor vehicles mechanics. Maintenance of the automation units is largely a matter or replacement following fault diagnosis by automatic check-out equipment. Operations need to be overseen by skilled operators but they will be relatively few in number.

During normal operations, vehicles can be inserted or withdrawn within minutes of making a decision to do so – to meet the needs of an unexpectedly large crowd from a public event, or to handle passengers unexpectedly diverted from another airport. Station platforms can be enclosed with platform edge doors permitting full air-conditioning. However, this may not be considered necessary when the service interval between vehicles or trains is short and the vehicles themselves are air-conditioned.

Costs
Figures presented here (which are not to be taken as a quotation) are based on estimates of U.K. production prices for a typical system to be installed in a U.K. city. All basic cost data is at mid-1974 prices and they have not been updated by either revised estimates or any index-sealing. Development costs and costs involved in planning and studies prior to installation are not included. Similarly, land costs for stations, depot etc. are not included.

Obviously total system cost will depend, amongst other things, on the route structure, service provided on each part of the route and the degree of sophistication built into stations. Thus the following costs are based on expected average values for a network of dual track which provides places for 5000 passengers per hour during peak periods over the whole route.

Table 1

Capital cost per kilometre of dual track

Infrastructure	£1.46m
Vehicles	£0.51m
Total	**£1,97m**

Infrastructure costs include:
Civil engineering of track and stations
Track fittings
Control equipment on the track, in stations and at central control
Depot and equipment
Power substations and power rails

——— public transport route

■ main interchange station

● station


TO ABU DHABI
TO ABU DHABI
TOWN CENTRE
INDUSTRIAL ZONE
ship repair yard
offshore engineering construction
PORT
dubal
ferrostaal
sunningdale gas plant
ferrostaal steel works
labour camp
dubai aluminium smelter
power station
TO DUBAI
reservoir
JEBEL ALI
wadi
INDUSTRIAL ZONE
INDUSTRIAL ZONE
INDUSTRIAL ZONE
INDUSTRIAL ZONE
FREE ZONE LINK
TO JUMEIRAH
TO DUBAI
EMIRATE HIGHWAY
AIRPORT
TO AL AYN
0 1 2 3 4 5 kilometers
0 1 2 3 miles

Operating costs for a typical traffic scenario involving peak flows of 5000 passengers per hour in the peak are given below.

Table 2

Annual operating costs per kilometre of dual track

Infrastructure maintenance and staffing	£35,000
Vehicle maintenance and operations	£32,000
Total (per annum recurrent)	**£67,000**

Vehicle maintenance and operation costs are proportional, mainly, to total daily traffic.

If fares on the system are charged to cover all costs including servicing the capital cost of the infrastructure then the lower the total traffic the higher must the fares be.

However, if the capital cost of the fixed facilities – track, stations etc. – is considered as a separate item, then the remaining costs are low and roughly proportional to the traffic, permitting low fares to be charged even at low traffic densities.

Where a minitram system copes with a high proportion of the peak transport requirements the separate cost item for fixed facilities can be more than offset by savings in the reduced total cost of road construction.

For a typical West European city, peak hour traffic of 5,000 passengers per hour is equivalent to some 12,000,000 passenger kilometres per annum per kilometre of dual track. Hence the operating costs quoted above are equivalent to about 0.6 pence per passenger-kilometre.

Maintenance

Maintenance activities are concerned with the vehicle, the fixed track and station structures, station equipment, main power distribution and the automatic control system in the vehicles and on the track. In all cases the type of work involved is traditional and similar to maintenance work carried out on a range of other city facilities.

The rubber-tyred vehicles involve no specialised railway track maintenance nor the use of heavy duty mechanical maintenance of vehicle running gear. The mechanical aspects of the vehicle involve skills similar to those required for normal road vehicle maintenance. However, a number of factors combine to reduce the amount of maintenance required compared with other types of public transport. These factors, of which the use of electric propulsion is of major significance, are listed below:–

Table 3

Comparison between the minitram and other urban transport systems

Road vehicle (bus)	Minitram	Conventional rail cars
Diesel engine with associate vibration and maintenance costs.	One electric motor/car	Two or more electric motors/car
9.6 tons/vehicle	5.5 tonnes/car unladen	28 tons/car
Two folding doors	Two double doors/car	Eight double doors/car
Many seats, and an interior which is awkward to clean	Simple interior for cleaning	Large interior for cleaning
Gearbox and rear axle transmission system	Simple transmission system	Gearbox and rear axle transmission systems
Kerbs and pot holes are negotiated	Smooth running surface	Smooth running surface

The automatic control equipment, though it performs a complex task, is amenable to simple maintenance procedures. Fault finding largely involves the use of automatic check out equipment to identify the faulty component which is then replaced on a component plug-in basis. In most cases it is cheaper to throw away the faulty component rather than attempt its repair.

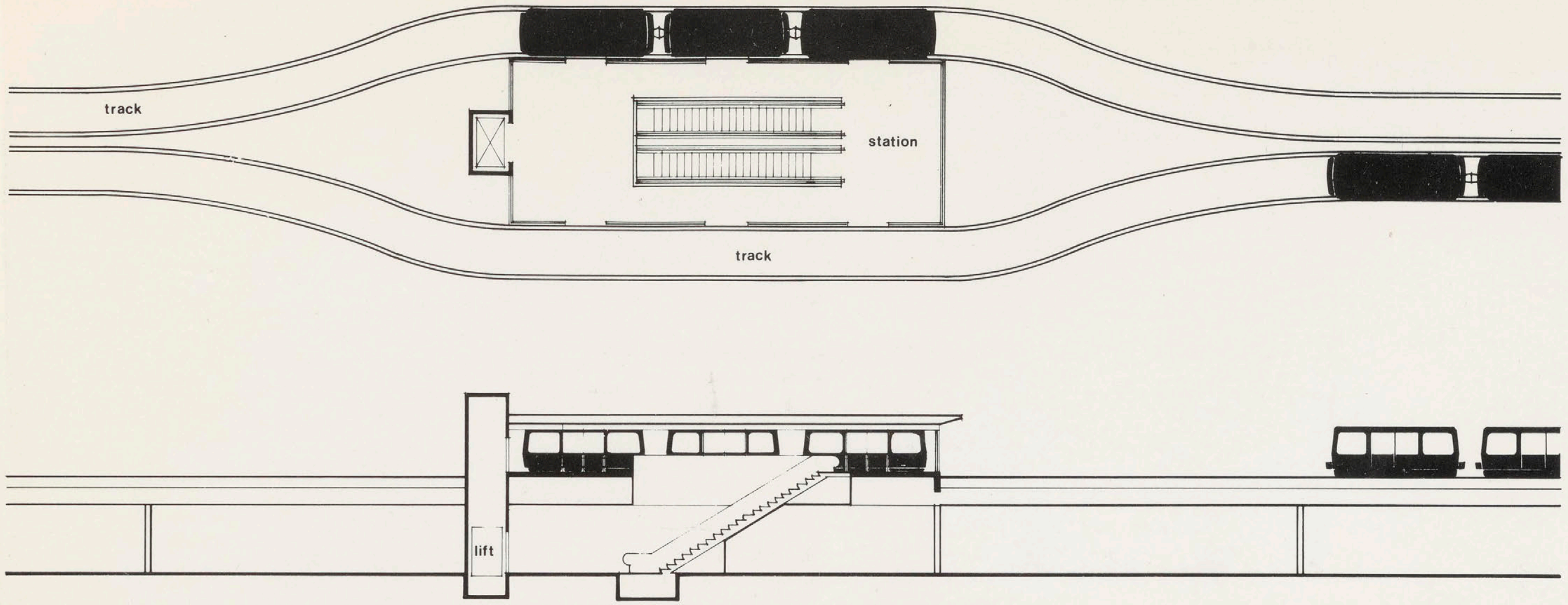
Though the range of skills required for all the sub-systems is somewhat wider than for some other urban transport systems the individual skills involved are no more than are required for many other urban facilities and the total number of employees involved is small.

Depot facilities

Depot facilities for the inspection, maintenance and overhaul of vehicles are similar to those required for heavy road vehicles. However, body repair shops will be less extensive (damage in service is far less likely than for road vehicles) and diesel engine overhaul facilities are replaced by facilities for electric motor overhaul. The segregated track on which the vehicles operate must be extended to run through part of the depot, mainly for parking vehicles out of service and it is convenient to move vehicles through the workshop using an overhead gantry; this permits a compact layout as shown in the attached figure illustrating a depot for a small minitram system with some thirty vehicles. Total floor area is some 65 square metres per vehicle; vehicle parking tracks in the open are additional

(v) Power requirements
Power is drawn from the local city electrical supply (probably at 11 kw) through sub-stations approximately 1 km apart. Here it is transformed to 415v and fed to the track via conventional medium voltage switch-gear.

The rating of sub-stations will depend on the peak passenger traffic and local topography but will be about 1.3 M.V.A. per route km on a level dual track route carrying 10,000 passengers per hour. Peak power demands occur only when vehicles or trains are accelerating and the rating is based on average consumption during peak traffic; average consumption over a day will depend on the variation in traffic throughout the day.



Island platform station

Mini Tram

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